IUGG Quadrennial Report Overviews

Hydrology 1979–1982

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The quadrennium 1979–1982 produced notable advances in surface water and groundwater hydrology, as well as important trends toward a more scientific basis for engineering hydrology. Examples of these developments will be given below, as well as an assessment of current trends.

One of the most significant areas to emerge during the last quadrennium is stochastic groundwater analysis. The basis for the conceptualization of groundwater flow and transport as a stochastic process is twofold: (1) the realization that hydrologeological environments are extremely heterogeneous, regardless of the scale of modeling or data collection and (2) the use of groundwater flow and transport modeling results within broader water resources or hazardous waste management studies where risk analysis requires and incorporates groundwater uncertainty.

The work over the last quadrennium can be grouped into three broad areas: (1) statistical analysis of parameters and inputs that influence groundwater, the main methodological approach being optimal linear estimation (kriging, state estimation), (2) stochastic prediction of model outputs, the main approaches including spectral analysis and Monte Carlo simulations, and (3) statistical analysis for groundwater model identification and parameter estimation. In all three areas, special sessions have been held at national and international symposia to disseminate results. While significant results have been obtained, much work remains in developing fundamental theory that relates the scale of the process to equation formulation in a manner that incorporates the heterogeneity of the medium. This work is critical to the groundwater transport problem.

During the last quadrennium, the awareness of groundwater contamination from hazardous wastes—especially chemical wastes—has grown. As data from waste sites are being collected and attempts to model contaminant transport are made, it is clear that current models and procedures are insufficient in at least two areas: (1) relationships among microscale heterogeneity, numerical model representation and data collection are not well coordinated at the landfill site scale, and (2) understanding of the chemical processes (for example, adsorption or desorption), biological processes (for example, degradation of chlorinated hydrocarbons), or physical processes (for example, relative conductivities or mixing properties of multiphase organics in saturated media) is incomplete.

Fundamental work, including both laboratory and field analyses, is required if progress is to be made at improving the predictive capabilities of groundwater transport models.

In surface water hydrology, progress has been made on several fronts. Most notable in the area of engineering hydrology are advances in the implementation of on-line flood forecasting systems. During the quadrennial period, fundamental advances were achieved in applying systems theory and state-estimation to on-line hydrological forecasting. These advances include model structure identification and parameter estimation, as well as embedding hydrological models within a state-space framework capable of the necessary feedback to incorporate on-line data. Some of the most important work has been in the area of parameter identifiability for conceptual hydrological models. Results indicate that the available data are insufficient to estimate all the parameters accurately—either the models need to be simplified or additional components of the hydrological budget need to be measured.

The implementation of on-line flood alert systems, coordinated by the U.S. National Weather Service, has grown by a factor of ten during the quadrennium, with the demand for such systems growing far faster than state and federal agencies can fulfill. The National Weather Service is leading the way in this important area. The most notable aspect is the desire of field hydrologists to incorporate recent research results into these systems. Internationally, this area is gaining in importance, as can be seen from recent conference devoted to flood forecasting (e.g., IAHS, 1980).

The current quadrennium saw consolidation rather than significant developments in the area of statistical hydrology. The last quadrennium ended with a conference on hydrologic data networks. Langbein (1979), in summarizing the conference, recommended five areas where the research results could be extended and applied to important data acquisition problems. These recommendations included: data transfer among stations (regionalization), broaden the scope so as to apply techniques common to surface water to other hydrological areas, carry out audits to see how networks fulfill current or modified objectives, investigate how data needs vary with water management objectives, and improve coordination among various data networks.

The general area of regionalization, as applied to flood frequency, has received more attention during the current quadrennium than other topics. The concern has been twofold: (1) development of statistical models and procedures that better represent flood data and (2) development of robust estimates using regional data in a hydrologically and statistically responsible manner. In the research community, there is wide belief that current operational methods should be improved.

Fundamental research into flow generation and basin structure has started to pull together work in widely varying areas: geomorphology, soil physics, surface hydrology, and statistical hydrology. A unifying theory for hydrologic responses at varying basin scales has not yet been developed; work during the last quadrennium focused upon various issues including 1) the basin response and flood statistics based upon its geomorphological structure, (2) soil variability and runoff variability, and (3) role of macropore flow, interflow, and contributing area surface runoff in the flow response. It is crucial that adequate and detailed data be available so that theories concerning runoff generation can be adequately tested.

In hydrology, the long-term trend appears to be a bifurcation of the field into scientific hydrology and engineering hydrology. Exciting developments in scientific hydrology will be made in all areas: equation formulation for porous media flow, advances in our understanding of hydrological processes at various scales, and improved statistical representation of hydrological processes in time and space. One hopes that equally exciting developments will occur in engineering hydrology. At present, one sees some very creative applications of research results—especially in the area of groundwater modeling. It is important for the engineering side of hydrology to understand recent developments and to apply them where appropriate; likewise it is important for those in hydrologic research to understand the problem faced by field and engineering hydrologists.

References

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Contents: IUGG Quadrennial Report
Hydrology

Geodesy 1979–1982

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The growing interaction of geodesy with its kindred disciplines, oceanography and tectonophysics, may have been the most significant trend in geodetic activity during this past quadrennium. Geodetic observing systems are now capable of measuring so much more precisely (to the centimeter level) and over such a broader extent (like the oceans); that their results add materially to knowledge of crustal and mantle structure, of ocean bottom relief, and of oceanic circulation. Especially important is the application of precise, repetitive geodetic measurements to the detection and analysis of time-varying effects. Examples are the utilization of altimeter data to yield ocean boundary current changes, and of radio interferometry and laser ranging to systematically monitor polar motion, earth rotation, and crustal movements.

There has also been an increased awareness of the value of classical observations of leveling and gravity for analyzing crustal structure and movement. Particularly in leveling, a large effort has been made to expose systematic aberrations so that the intrinsic precision of the measurements can be properly exploited.

A perusal of the presentations at the semiannual meetings of the American Geophysical Union over the past 4 years indicates not only that a major portion of the geodetic sessions has been devoted to these topics, but that many papers in the oceanography and tectonophysics sessions employ geodetic theory and observations to an extent never evident before.

The traditional tools for making geodetic observations are in the process of giving way to more rapid, precise (and complicated) devices. Inertial surveying systems have already yielded operational results, and the Global Positioning System is on the verge of doing likewise. The report for the next quadrennium will undoubtedly feature the consequences of this incipient revolution in geodetic surveying methods.

In contrast to the period 1975–1978 during which Geos 3, Lageos, and Seasat were launched, no comparable satellites became operational within the period under review. This circumstance, however unwelcome, forced scientists to thoroughly scrutinize the data recently amassed. Visible examples of this emphasis on analysis were two special issues of the *Journal of Geophysical Research*, Vol. 84 (B8), June 30, 1979, on Geos 3; and Vol. 87 (C5), April 30, 1982, on Seasat.

During the past 4 years, the American geodetic community benefited from the guidance provided by several committees of the National Research Council, U.S. National Academy of Sciences, especially the Committee on Geodesy. The work of these committees is delineated in a series of reports which furnishes an excellent panorama of the geodetic interests prevalent today in the United States. These publications by the National Academy of Sciences, Washington, D.C., are: *Impact of Technology on Geophysics*, Geophysics Study Committee (1979); *Applications of a Dedicated Gravitational Satellite Mission*, Committee on Geodesy (1979); *Need for a Multipurpose Cadastre*, Committee on Geodesy (1980); *Geodetic Research and Development in the National Ocean Survey*, Committee on Geodesy (1980); *Federal Surveying and Mapping: An Organizational Review*, Committee on Geodesy (1980); *Geodetic Monitoring of Tectonic Deformation—Toward a Strategy*, Committee on Geodesy/Committee on Seismology (1981); *Modernization of the Public Land Survey System*, Committee on Integrated Land Data Mapping (1982).

Special symposia on geodetic topics held in the United States for the period 1979–1982 were: Second International Geodetic Symposium on Satellite Doppler Positioning, Austin, Tex. (January 22–26, 1979); Radio Interferometric Techniques for Geodesy, Westford, Mass. (June 19–21, 1979); Ninth International Symposium on Earth Tides, New York, N.Y. (August 17–26, 1981); Third International Geodetic Symposium on Satellite Doppler Positioning, Las Cruces, N.M. (February 8–12, 1982).

One reason for this comparatively small number compared to the two previous quadrennia is that other countries have been sponsoring more international meetings. U.S. scientists have participated actively in, and U.S. organizations have cosponsored, many symposia taking place elsewhere.

However, the chief indication of the continued vitality of geodesy in the United States is not displayed by conference activities but by the evidence of theoretical and practical results as manifested in the following reports on specific accomplishments, and the accompanying bibliographical records. These certainly are not complete. The proliferation of geodetic pursuits and applications has rendered more difficult than ever the task of encompassing within these reviews the entire field of endeavor. Following the precedent of the editors of the previous two quadrennial reports, I apologize for inadvertent omissions.

Contents: IUGG Quadrennial Report
Geodesy

Seismology 1979–1982

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The years 1979 to 1982 have been marked by a continuing expansion and development of seismology in the United States. In this introduction, we summarize some of the highlights of this period as a prelude to the more detailed papers that follow. These papers cover improvements in our understanding of earth processes together with improvements in the various geophysical techniques available to study them.

Perhaps the most traditional area of seismology is the study of the structure of the earth's interior, though recent developments are following most untraditional directions. Highlights of this area include significant new information on lateral heterogeneity, anisotropy, and the mechanisms of scattering and attenuation. Using a variety of techniques, we are beginning to identify the regions of the earth that are the most heterogeneous and to characterize the heterogeneity in those regions. The upper mantle has long been known to contain lateral variations, particularly in the uppermost part. New data are beginning to suggest substantial heterogeneity in the transition region between 400 and 670 km depth. In addition, more evidence is confirming lateral variations in the lower 200 km of the mantle. Attempts to relate these various heterogeneities to tectonic processes at the earth's surface and motions in the earth's core are continuing.

Attempts to establish a reference earth model that is in some sense a best fit to a wide variety of seismological data are approaching completion. An interesting conclusion of this work was that the overall fit can be improved by the inclusion of elastic anisotropy in the upper 220 km of the earth's mantle. This anisotropy is transverse, with a vertical axis of symmetry. Regional studies have often indicated some degree of both transverse and azimuthal anisotropy. We are now beginning to assemble these observations into a consistent picture which will, hopefully, relate in some way to convection processes.

Scattering and attenuation have long been of interest for two reasons. First, we need to understand more about the physical mechanisms of attenuation at a wide range of frequencies. Second, the seismic aspects of test-ban treaty verification require that we be able to correct for attenuation in order to make accurate estimates of seismic yield. While we continue to refine the large-scale variations of the attenuation parameter Q using normal modes, some interesting new results are providing information in the short-period band. It seems likely that there may be a significant frequency dependence of Q in the 0.8 to 1.5 hz range, corresponding to a simple relaxation band in pure shear. Regional variations in attenuation, and complications due to scattering, are known to occur, but many details of these phenomena are not well understood.

Seismic studies of the earth's crust have continued to expand during the last four years and now represent perhaps the most active area of seismology. Many of the techniques that have been perfected in the exploration industry are now being applied to the study of the earth's crust (particularly the deep crust) and upper mantle. At the same time, we are developing ways of generating synthetic seismograms for a wide variety of structures and are moving towards the application of inversion methods to determine structure.

U.S. activities in crustal seismology have been dominated by the continuing Consortium for Continental Reflection Profiling (COCORP) project, a portable 100 station array built by the U.S. Geological Survey (USGS), and an increased use of marine multichannel systems. COCORP continues to make detailed investigations of important structures in the United States and is contributing valuable new data to the regional geologist. Particularly interesting results were obtained in the Wind River Mountains of Wyoming, the Rio Grande Rift zone, and the Appalachian Mountains. The deployment of a large digital array in the Snake River Plain has clarified the transition from the Plain to the Basin and Range province. Other studies in California have provided valuable information on the Imperial Valley and the Mohave Desert regions. Marine studies using both reflection systems and ocean bottom seismometers have tended to focus on the continental margins. Here it has been possible in a number of areas to clarify the sedimentary col-

U.S. National Report to IUGG 1979–1982

Eos is periodically publishing the 13 overviews appearing in the *U.S. National Report to the International Union of Geodesy and Geophysics 1979–1982*. The U.S. National Report was published by AGU on behalf of the U.S. National Committee in four extra issues of *Reviews of Geophysics and Space Physics* (RGSP). The discipline overviews appearing here were published with their associated papers (see Contents list at the end of the each overview).

Subscribers to RGSP will automatically receive the four extra RGSP issues containing the U.S. National Report, which were mailed in June 1983. The four regular issues of RGSP are appearing as usual in February, May, August, and November. Those who do not subscribe to RGSP can still obtain the entire U.S. National Report by entering a subscription to RGSP. In addition, the report of each discipline is automatically mailed separately to those members of AGU for whom that discipline is their primary AGU section affiliation; this separate distribution is made possible by grants from the Defense Mapping Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Science Foundation, Office of Naval Research, and U.S. Geological Survey.

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Particles and Fields—Magnetosphere

umn and its structural relationship to the continental basement.

The crustal seismology studies overlap with many other investigations in the general area of seismotectonics, the study of processes in active regions. In this area, improved techniques in hypocenter location, long period body wave modeling, and routine estimation of the seismic moment tensor have led to new insights into the faulting process. The characteristics of subducting slabs continue to be explored. Complexities in slab shape due to very shallow dipping subduction in some regions have been established. At deeper depths, more and more slabs are being demonstrated to contain clearly separated seismic zones, though the processes involved are still open to question. Interpretations of data collected during the Rivera Ocean Seismic Experiment (project ROSE) are now being published. These have provided detailed information on the relationship between seismicity and structure near a mid-ocean spreading ridge. Some events were clearly related to a topographic trough, while others were not obviously related to topography of the sea bottom. In another area, a number of investigations are beginning to unravel the complex tectonic processes at work in the Caribbean region.

In the field of earthquake prediction, progress in understanding short-term precursors has been slow. Efforts have been focused on improving our understanding of the nature of the earthquake process and its relationship to host rock and fault gouge properties. Modeling shows distinct promise, and we are beginning to understand the ways in which complexities in prestress distribution and rock properties influence fault propagation and stopping. More success is being identified in the area of long-term predictors. Estimates of recurrence rates are constantly being improved, and the seismic gap concept has been successfully applied to the actual prediction of two earthquakes. The continued high level of research activity in earthquake prediction suggests that we are slowing moving towards real success in this field.

Research in theoretical seismology has concentrated primarily on the synthesis of near, regional, and far field waveforms due to a variety of source models. In the near field, a number of techniques have been developed to take account of local structure. However, much remains to be done in including the complexity of the seismic source, which is the dominating factor at high frequencies. The construction of regional synthetics has been spurred by the test ban treaty verification program and is making substantial progress. Modifications to the classic Thomson-Haskell technique allow the calculation of P-SV and SH synthetics in a variety of structures. In the far field, the emphasis has been mainly on the inversion of network waveforms to derive the seismic moment tensor. Other theoretical studies have continued work on the dynamics of fault rupture, and wave propagation from explosive sources.

The field of strong motion seismology has grown rapidly during the last four years. The measurement, interpretation, and prediction of near field ground motion due to earthquakes has been impacted by a substantial growth in the number of instruments deployed, in the amount of data available, and in the interest of agencies concerned with hazards reduction and potential damage to critical structures. Over 2700 strong motion accelerographs have now been deployed in the United States. While most of these are analog instruments, from which the data need digitizing for processing, there are an increasing number of digital instruments. The 1979 Imperial Valley earthquake generated a particularly extensive data set that has been the basis for many investigations. Near field waveforms are affected by source characteristics, propagation path, and site response. While all are important, our ability to predict strong ground motion is apparently most limited by our understanding of the seismic source.

The increasing use of digital instrumentation has not been limited to the strong motion area but is taking place throughout seismology. Most importantly, we are establishing a global network of digital seismic stations, consisting of the Seismic Research Observatories (SRO's) funded by DARPA and managed by the USGS, and the stations of the WWSSN network that have been upgraded to digital capability by the USGS. The dynamic range of these instruments has already proven their immense superiority over the older analog seismograms. At the same time, the amount of data generated is large, and we are still in the process of establishing data management techniques that will make the data easily available to the seismological community. In spite of this, the new digital data have made very significant contributions in virtually all areas of seismology, and we expect this to increase in the future.

While it is impossible to cover every single area of seismology, the review papers that follow show clearly that seismology is an active, exciting field that is having an important impact on many fields of geology and geophysics.

Contents: IUGG Quadrennial Report Seismology

News

EGT Project

The European Geotraverse (EGT) has been planned as a major geoscience project that will run for 5–7 years involving collaborative efforts of geophysicists, geologists, petrologists, geodesists, and other geoscientists from different European countries. A first draft proposal was elaborated in 1981 by a Working Group of the European Science Research Councils (ESRC), a standing committee of the European Science Foundation (ESF); it was subsequently modified following the amendments requested by the ESRC and was finally approved by the General Assembly of the ESF on November 9, 1982.

The broad aim of the EGT is to secure an understanding of how the continental lithosphere formed and reacted to changing physical and geometric conditions through time. One of the best locations for such a study is Europe because it is made up of a number of tectonic provinces ranging in succession from the oldest Precambrian areas of Scandinavia to the currently active area of the Mediterranean. The concept of a geotraverse has been chosen in order to provide a continuous, integrated study of sufficient scale to cross this whole region like a swathe that will give new information about the dynamics and vertical and lateral variations of the lithosphere, both within and between adjacent provinces.

Geophysical and geological surveys carried out so far have revealed important features relevant to the objectives of the EGT. At the same time, however, they have disclosed a number of fundamental problems that can only be tackled within the framework of a wide-scope, multidisciplinary, large-scale project.

Extending from the northern tip of Scandinavia southward to North Africa the EGT is located to encompass the pre-2500 Ma old Archaean nucleus in the northernmost part of the Baltic shield; the Proterozoic, Paleozoic, and Cenozoic provinces of northern and central Europe that have been added on to this nucleus; and the active transition zone between the Eurasian and African plates in the Mediterranean area.

The EGT has been chosen such that—proceeding from north to south—a 4000-km-long section is obtained which, in three segments, covers the whole time span of the history of the continental lithosphere. From a tectonic-geologic point of view, Europe can be divided into three main units: (1) the Precambrian shield of Fennoscandia (age ~3100 to ~600 Ma) with its border regions, including the Caledonides (age ~600 to ~400 Ma); (2) the Hercynian (Variscan) realm of central and western Europe (age ~400 to 230 Ma); and (3) the Alpine-Mediterranean region (age 230 Ma to present).

A thorough understanding of the tectonic processes requires detailed knowledge of the structure and dynamics of the whole lithosphere, including not only the crust but also the underlying mantle, which is intimately bound up with it.

A large-scale geotraverse is required both to provide lateral continuity of information across the major structural elements of Europe and to achieve a deeper view of variations within the lithosphere. It is intended that the results of the investigations will be integrated to produce a north-south section through the crust and upper mantle of Europe which will provide the basis for a reconstruction of the evolutionary development of the various provinces of Europe and their mutual interaction. This should provide a better insight into the structure and dynamics of the lithosphere-asthenosphere system, which in turn will be of general scientific benefit. Although certain techniques are proposed for the full length of the EGT to provide continuity and depth of information, most of them will be applied selectively so that the combination of methods utilized will be those most appropriate to the particular problem under investigation. Vital to the concept of the EGT is that it should be carefully directed and contain within its broad-scale framework a number of linked experiments with specific geological objectives to derive the detail that is essential.

The goals of all these various experiments can only be accomplished by close international cooperation. Since the aims of the EGT require a continuity of information on a large scale, it is mandatory for these investigations to be carried out in the form of a "Joint Program."

Two specific projects where the scientific objectives are essential to the aims of the EGT, but which cannot be realized along the EGT as such, have also been included in the EGT Joint Program. They are of fundamental importance to the understanding of the crust and mantle in Hercynian Europe.

EGT Joint Program

1. Simultaneous geomagnetic observations along the EGT.

2. Mapping of the resistosphere and conductosphere along the EGT.

3. Mapping of the lithosphere-asthenosphere system by seismological techniques along the EGT (seismic surface waves, crustal transfer functions, and P delay studies).

4. Deep seismic sounding of the lithosphere (southern segment of the EGT).

5. Multidisciplinary (tectonic stratigraphic sedimentological, petrological, geochronological, paleomagnetic, and anisotropy) studies as well as synoptic geophysical surveys in the Southern Alps, Po Valley, and Northern Apennines.

6. Deep seismic sounding of the lithosphere (central segment of the EGT).

7. Synoptic geological and geophysical studies of border regions between different tectonic units of Hercynian age (central segment).

8. Multidisciplinary study of the contact zone (Tornquist-Teisseyre Line) between Precambrian and Hercynian Europe (southern Norway–southwestern Sweden, Denmark–northern Germany).

9. South Scandinavian east-west traverse: a multidisciplinary study across Svecononorwegian crustal units, the Oslo rift, the Protogine zone, the Småland-Värmland granite belt, and into the Svecofennian province.

10. Multidisciplinary studies of the evolution of the Baltic Shield (seismic, magnetotelluric, paleomagnetic, radiometric, and tectonic studies along the FENNOLORA Traverse and adjacent areas).

11. Large-scale anisotropy study of the upper mantle in the Hercynian domain of Iberia.

12. NARS; A wide-aperture seismological array surveying the upper mantle along the traverse Göteborg-Malaga (down to a depth of about 600 km).

Some of the experiments listed above making up the EGT Joint Program are already in an advanced stage of planning (such as experiments 4 and 8) and are scheduled to be carried out in 1983 and 1984, respectively. One of the studies (experiment 12) is already in progress. Steps toward the planning of the other projects have been undertaken by various geological and geophysical institutions in a number of European countries.

Those experiments contributing to the basic objectives of the EGT on a regional and more detailed scale that can be realized as part of national or multinational programs are included as "Regional Studies." They are quite numerous and, therefore, for the sake of brevity are not listed here.

Organization and Coordination

A multidisciplinary international program of the size and duration outlined above will need an organization and coordination that secures the steady progress and realization of the EGT objectives. An EGT Scientific Coordinating Committee was formed to supervise the compilation and the inventory of the data and results relevant to the EGT. It will also identify and encourage those research proposals that meet the objectives of the EGT.

Three sectional groups, one for each of the northern, central, and southern segments of the EGT, will plan in detail and supervise the execution of the Joint Program and advise on those regional studies to which priority shall be given.

The ESF Secretariat in Strasbourg will assist the Scientific Coordinating Committee in administrative matters and ensure the organization of sectional and regional working group meetings. It will also help in synchronizing the various activities, channel information, and organize an annual workshop of scientists who actively participate in the EGT.

Since the realization of the Joint Program, running for a period of 5–7 years, requires funding beyond the scope of an "Additional Activity" of the European Science Foundation (ESF), it was proposed that contributions to this program would have to be secured on a national level by the appropriate funding agencies. The ESF in agreement with its primary role will coordinate the implementation of the national efforts.

A separate budget for the costs of "Coordination" has been established within the framework of an Additional Activity of the ESF, which is financed by contributions from the participating member organizations already agreed upon at the last ESF General Assembly in November 1982.

The Regional Studies will have to be funded by the appropriate national agencies according to the specific scientific interests and needs of the different countries and the available financial means.

The members of the EGT Scientific Coordinating Committee are St. Mueller (Zürich, chairman); A. Berthelsen (København); P. Giese (Berlin); C. Morelli (Trieste); D. Blundell (London); H. Zwart (Utrecht); A. Hirn (Paris); E. Banda, Scientific Secretary (Institute of Geophysics, ETH-Hönggerberg, CH-8093 Zürich, Switzerland).

Further information can be obtained through the Scientific Secretary or through B. Munsch, Secretary of the EGT at the European Science Foundation, 1, Quai Lezay Marnésia, F-67000 Strasbourg, France.

This news item was contributed by Stephan Mueller, Institut für Geophysik, ETH-Hönggerberg, CH-8093 Zürich.

ERL Director Resigns in Protest

George H. Ludwig resigned in protest last month from his post as director of the National Oceanic and Atmospheric Administration (NOAA) Environmental Research Laboratories (ERL). Ludwig, who will retire in February 1984 after 30 years of government service, told *Eos* that he resigned "with the intent of making a statement" about changes within NOAA that he says are weakening the agency's research program. Ludwig is now the assistant to the National Aeronautics and Space Administration's (NASA) chief scientist.

"The NOAA reorganization process of the past year has been unusually traumatic for ERL," Ludwig explained in a memo to his ERL colleagues when he announced his departure. "Specific actions have shifted many of ERL's long-standing management responsibilities elsewhere in the [Department of Commerce] and NOAA."

He cited "the movement of most of our research support services (including management of the Cyber 750 research computer and library)" to the NOAA/Commerce Department administrative support centers, "our loss of most of the funds appropriated to solve our computing needs over the next decade, and the impending transfer of our research aircraft to the NESDIS [National Environmental Satellite Data and Information Service]." He told *Eos* that he feels the movement of these support services away from ERL means that these services will be less responsive to NOAA's research needs because the management control would be farther away from the research organization.

"This process has recently progressed to the point where decisions have been made before I was even given an opportunity to discuss them. This state of affairs clearly reflects a difference of opinion about the level of resource control and programmatic authority required by the ERL director," Ludwig told his colleagues. "Although I have never argued for complete autonomy without responsible planning and accountability, I have consistently held the position that many elements of administrative decision making and the control of the tools of research should be at a level where the details of the research programs and of the process of research are clearly understood. In many instances this will no longer be the case, and I expect that the research program will suffer."

Neither NOAA Administrator John Byrne nor NOAA Deputy Administrator Anthony J. Calio has given an official reaction to Ludwig's resignation. However, Byrne told *Eos* that he is "disappointed that he [Ludwig] resigned" and attributed the resignation to a sense of fatigue and frustration with the increasing bureaucracy placed on government employees, particularly with an administration that has altered the structure of government. Byrne also said that in the past few years NOAA has become closer to, and is doing more work in concert with, its parent Commerce Department. This could cut into the flexibility of middle level managers, Byrne said; he suspects this may have played a role in Ludwig's resignation.

Ludwig, a codiscoverer of the Van Allen radiation belts, joined ERL in 1980 as a senior scientist, coming from a management position in the satellite service. It was a conscious move, he said, to go back to research. In August 1981, he succeeded Wilmot Hess, now director of the National Center for Atmospheric Research, as ERL director.

When Ludwig became ERL director, he and NOAA Administrator Byrne discussed whether an ERL director was needed and whether the ERL director should be based in Boulder, Colo. "I felt we had an excellent basis of agreement," Ludwig said. One year later the entire issue arose again. The NOAA reorganization that was suggested in early 1982 included plans to coalesce five of the nine current ERL laboratories by combining them into a single regional laboratory. In this concept, the five current environmental research laboratories would have been downgraded to "program elements." Last August, though, NOAA Administrator John Byrne decided not to reorganize ERL. Since then, Ludwig says, a series of small but substantive changes have altered significantly the management of research support services for ERL's program.

"Many of the changes which have actually occurred are, I believe, serving to weaken, rather than strengthen, NOAA's research activities," Ludwig told the ERL laboratory directors and staff when he announced his resignation. Nevertheless, he told *Eos*, he still believes strongly in NOAA. He said he hopes his resignation will serve as a constructive step and that it will focus increased attention on the strengths of the NOAA research program.

In the late 1950s while at the University of Iowa, Ludwig worked with James Van Allen and shared in the discovery and early delineation of the Van Allen radiation belts. After earning his Ph.D. at Iowa in 1960, he worked at the Goddard Space Flight Center in various capacities for a dozen years and then went to several management positions at the satellite service. Ludwig received the NOAA Program Administration and Management Award in 1977, the NASA Exceptional Service Medal in 1969, and the Academy of Achievement Golden Plate Award in 1962. Also that year he was pictured in *Life* magazine as one of 100 outstanding young men. He is a member of the Committee on Data Management and Computation of the National Academy of Sciences.

At NASA, Ludwig will work on space research data management. As part of the project, he will examine existing policies and general practices for the acquisition of data on space and will look closely at how such data are distributed, processed, and archived for research. The project aims to lay a foundation for future data management and policy formulation.

A search for a new ERL director is in the initial stages.—*BTR*

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Cover. The continental crust of Europe is divided into four tectonic realms, from oldest to youngest: Precambrian Europe, Caledonian Europe, Hercynian Europe, and Alpine Europe. Within each realm a further subdivision is shown, according either to the age or style of deformation, to the age and nature of the rocks involved, or to the intensity of accompanying metamorphism and/or magmatism. Precambrian Europe (~3100–600 Ma) comprises (1) the Baltic Shield, with exposed Precambrian crust, and the East European Platform where Precambrian crystalline rocks occur beneath younger sediments (except in the Ukrainian Massif where the basement has been uplifted and exposed) and (2) the buried Precambrian basement of the Midland Craton–Brabant Massif (stretching across the English Channel). Tectonically, the Precambrian crustal region of northwest Scotland and the Outer Hebrides belong to the North American–Greenland Shield. Caledonian Europe (~600–400 Ma) encompasses the British–Scandinavian Caledonides and the north German–Polish Caledonides. The supposed collision suture in the British Caledonides is shown with a dotted line. Most of the north German–Polish Caledonides is deeply buried beneath younger sediments. Hercynian Europe (~400–230 Ma) once formed a wide mountain belt (the Hercynides or Variscan mountains), but is now composed of a number of massifs of varying size, and intervening areas with Hercynian basement. The supposed Hercynian collision suture is shown as a dotted line. Alpine Europe (~230 Ma to present) comprises the young mountainous regions north and south of the Mediterranean, formed in relation to the collision between the indented Eurasian and African plates. In pre-Alpine Europe, incipient rifting initiated the formation of the Rhône-Bresse-Rhine graben system around 50 Ma ago. The Mediterranean region is presently subjected to strong tectonic activity. (See news item p. 458.)

Z^0: The Extra Force

Researchers at CERN (European Center for Nuclear Research) have reason to believe that they have finally observed the elusive superheavy Z^0 nuclear particle. The observation is important because it represents the unifying link between the physics of weak-field phenomena and electromagnetic forces. The Z^0 particle was predicted by the Salam-Weinberg model, which is an attempt to pull together all physical forces into a single field theory. The as yet uncalibrated experiments at CERN project the new particle's mass at 95 ± 5 GeV, or about the equivalent to the combined masses of 95 protons. What remains in the search for such nuclear particles are "heavier Z^{0}" particles (200 GeV), "top quarks," and "Higgs particles," all of which are parts of the Salam-Weinberg model.

The Z^0 particle is related to, and in some way analogous to, the photon (though much more massive). Photons and Z^0 particles are both involved in electromagnetic forces, but Z^0 carries an extra force, which is the weak field contribution that results in a violation of parity. The Z^0 is considered the link between weak interactions and electromagnetic fields because it benignly mediates both.

The discovery of the Z^0 particle may mark the end of the experimental road for the pioneering aspects of particle physics. In a report about a recent discussion of the finding of the particle, R. Walgate says that further steps to test the grand unified theories will require comparatively high energies, on the order of 10^{19} GeV or higher. These energies are not feasible in any existing or planned facility (*Nature*, June 9, 1983).

The path of experimental research leading to discovery of the Z^0 was exciting, elegant, and perhaps was sufficient evidence of weak field existence in itself. F. Close described experiments to test for the "tell-tale signature" of the presence of the extra (weak) force. The parity violation, or departure from mirror plane symmetry, if detected, is a measure of weak force interaction. In parity-conserving interactions, the weak field effects are manifested in other ways. Indeed, experiments with left- and right-handed (polarized), high-energy electrons have demonstrated small violations of mirror symmetry. Likewise, experimental electron-position (collision-annihilation) processes have been controlled to detect weak fields by analyzing the resulting antimatter equivalents.

As was described by Close (*Nature*, May 26, 1983) "If the electron-position annihilation were controlled only by the electromagnetic interaction, then processes that produce μ^- and μ^+ (muons and antimuons) would yield the μ^+ in the forward hemisphere marginally more often than in the backward. (Momentum is balanced by the μ^- emerging in the other hemisphere.) If the weak interaction also plays a part, as in the Salam-Weinberg model, the μ^+ should emerge more often in the backward hemisphere." Close goes on to describe that this is exactly what has been observed.

The new CERN experiments involved proton-antiproton collisions in a device that is fed by the Super Proton Synchrotron (SPS). As the high-brilliance, high-energy beams collided, numerous particles were released, including weak-field charged particles (w^+ and w^-) and the neutral Z^0 particles. The decay of these particles produced tracks in the facility's gas-filled image chamber. As a Z^0 decays, an electron-position pair is emitted, the two producing diagnostic straight-line tracks in opposite directions.

New directions in the study of electro-weak field theory, and its unity with electromagnetic field theory, will first involve improvements in the beam quality of the particle colliders. Higher energy experiments probably will not be obtainable in this decade. According to R. Walgate (*Nature*, June 9, 1983), "Another possibility is to search for Centauro events, seen a few times in cosmic rays, which indicate that a new kind of physics may set in at energies not much above present values."—*PMB*

New Pulsar Discovered

The discovery of a fast-spinning pulsar that is part of a binary system may provide a key to resolving the controversy over the nature of pulsars. Valentin Boriakoff of Cornell University, working with two Italian astronomers, Rosalino Buccheri and Franco Fauci, discovered the pulsar and its companion by using the 305 m radio telescope of the National Astronomy and Ionosphere Center near Arecibo, Puerto Rico. The astronomers concluded that the newly discovered pulsar is part of a binary system because its pulsing period is not constant, a sure sign that something else is in the vicinity.

Spinning at 163 times per second, the pulsar is rotating slower than the pulsar discovered at Arecibo last November (642 times per second), but the binary nature of the new discovery may help answer the question whether

News (cont. on p. 460)

News (cont. from p. 459)

a pulsar's rate of spin is accelerated by the transfer of mass from a companion or whether a pulsar comes into existence already spinning. Most astronomers consider pulsars to be remnants of supernovas or exploding stars that collapsed into extremely small, dense objects and emit intense short bursts of radiation at regular intervals.

Designated P1953+29 for its coordinates in the sky between the constellations Vulpecula and Cygnus, the pulsar orbits its companion every 120 days. The pulsar is 11,500 light years from earth and has a diameter of about 9.5 km. Its mass has not been determined. Two unique features of P1953+29 are the emission of radiation for at least 42% of its rotational period (an unusually high rate for a pulsar with this particular spin rate) and its drastic changes in pulse shape at different receiver frequencies.

P1953+29 was discovered when the astronomers were searching the sky for fast-spinning radio pulsars in an area where a satellite had previously discovered some point sources for gamma rays. Because P1953+29 is located close to one of these point sources, the astronomers will try to find a physical association between the pulsar and the source by conducting simultaneous observations by using the Arecibo telescope together with other experiments. One of the first such projects is a simultaneous observation with the balloon experiment FIGARO, a French-Italian joint venture scheduled for release in Brazil in late 1983.

Synchrotron Advances

Mineral physics studies, which gain precision as time decreases during a measurement, will benefit greatly from the availability of beams existing from synchrotron facilities. Unusually intense radiation is emitted from a synchrotron in the broad spectral range from the infrared through the X ray region and beyond. For example, X rays, which are released from such a facility at intensities of 10^5 times those of conventional generators, can be used for studies of mineral structures, such as XFAS (X ray fine structure) and photoionization, which were unthought of only a decade ago.

One reason for this new capability is that accessories for synchrotrons called wigglers and undulators have evolved from the laboratory-curiosity stage to useful devices during the same period. These new devices step up the brilliance (flux per steradian for a unit source area of a narrow wavelength band) of a synchrotron-produced beam and can be adjusted so as to extend the spectral range of the radiation. The truth is that most of the old and even the new synchrotrons were designed or planned without the knowledge that wigglers and undulators would be successful, according to a recent report (*Physics Today*, June 1983).

Now a number of totally new synchrotron facilities are being proposed that will contain a large number of wiggler and undulator magnets, and, essentially, will not even make use of the normal radiation yielded by the synchrotron bending magnets. Wigglers and undulators are, of course, being adapted to existing facilities and to those under construction currently. All of this recent upgrading of synchrotron radiation beams will benefit state-of-the-art mineral physics studies.

What is synchrotron radiation, and what are wigglers and undulators? Electrons and positrons are the charged particles that are accelerated around a circular path in a synchrotron. The curved motion is the steady-state acceleration (change in direction) and this causes the particles to lose energy. Synchrotrons were originally designed to study or otherwise employ the high-energy, charged particle beam, not the white radiation that is emitted as the energy loss due to the curved motion in a magnetic field. This white radiation had been thought to be of potential future use in physical measurements. It is this radiation that is being exploited for mineral physics and other condensed matter studies.

The standard bending magnets in a synchrotron yield intense, broad, fan-shaped beams of radiation (for electrons of 1 GeV the cone angle of emitted radiation is about 1 mrad). For X ray diffraction studies of minerals, however, the wavelengths are not sufficiently short and simultaneously intense after passing through collimators and monochrometers to be of significant improvement over conventional X ray generators.

Wigglers and undulators are periodic magnets that can be inserted in the sections of an electron storage ring that are free of other magnetic fields. These devices cause electrons passing through their fields to curve around and accelerate over relatively short distances and thus radiate the energy they lose in the process. The resulting radiation is a very narrow beam of greatly enhanced brilliance and extended wavelength.

The five synchrotron facilities in the United States are SURF (at the National Bureau of Standards in Maryland), CHESS (at Cornell University), SPEAR (at Stanford University), Tantalus and Aladdin (at the University of Wisconsin), and NSLS I and II (at Brookhaven National Laboratory). They are already in service in mineral physics studies, a few examples of which are instantaneous, single-crystal X ray structure determinations; high-pressure, diamond cell in situ, X ray diffraction measurements; bonding studies by energy-dispersive XFAS; and electronic structure measurements by photo-emission, in which the white synchrotron radiation can be tuned to observe the electron levels.—*PMB*

AIPG Membership

Members of AGU now are qualified to apply for membership in the American Institute of Professional Geologists (AIPG). The constitution and bylaws of the geologists' association require that applicants for membership hold prior membership in one of the societies affiliated with the American Geological Institute or in other scientific societies specifically approved by AIPG; AGU has been approved by the executive committee.

For additional information, contact AIPG national headquarters at 7828 Vance Drive, Suite 103, Arvada, CO 80003 (telephone: 303-431-0831).

Is Space for Ordinary People?

A blue ribbon Advisory Council to the National Aeronautics and Space Administration (NASA) recently reported the results of its 1-year study on whether to send private citizens on space shuttle missions. The answer from this panel, which was made up of an astronaut, a physician, several major space industry executives, and the author James A. Michener, was yes. If this result is acted upon, private citizens may fly on a shuttle mission in this decade.

The NASA Advisory Council claimed at the outset that the concept is not to be misconstrued as a self-serving public relations program. The main objective, it would appear, is for laymen to provide real functions in space missions; they could add a valuable dimension to the missions, if only by communicating first-hand space experiences to the general public. But, in addition to the widespread public interest in space, ordinary citizens are needed now and in the future: In-space technological manufacturing plants appear to be a good bet in a decade or so, and civilians can contribute to readiness programs as they work with highly specialized astronaut pilots.

Results of feasibility analysis of the private citizen in space are summarized as follows:

(1) Individuals can be flown by NASA without undue risk to either crew safety or accomplishment of the specific mission.

(2) Seats will be available, but there will be competing demands for them. Planning for a minimum program at this time is the best way to ensure seats for this opportunity.

(3) The flight experience is not particularly stressful if the person is trained in what to expect. If trained, one could adapt easily to the habitability requirements and the mission activities.

(4) The medical requirements will not be as rigorous as those for astronauts. They will focus on preventing medical/psychological situations developing in space that are hazardous to any or all who are involved.

A large part of NASA's objectives with the space shuttle program consists of addressing commercial and national security needs by gaining worthy experience in space. According to the Report of the NASA Advisory Council:

"The Space Act authorizes NASA to provide the widest practicable and appropriate dissemination of information concerning NASA's activities and the results thereof (203(a)(3)) and to foster 'the preservation of the role of the United States as a leader in aeronautical and space sciences and technology' (102(c)(5)). NASA has been conducting effective information and education programs under this charter for some time. Persons who would produce more comprehensive mission documentation and educational material would significantly implement NASA's charter and augment its current activities."

Private citizens they may be, but the choice of the first several individuals will be the result of rigorous procedures, not only because of physical and medical considerations, but because their important contributions to the tasks of the space shuttle are in rather critical need. NASA needs capable help in space right now by people of various disciplines, people who can go on a space shuttle flight with as little as 100 hours of training in a 2-month period, not 5 or more years as is the case with shuttle astronauts.

Eventually, the program will be expanded. The current plans are to have an observer-in-space program of narrow scope but of great potential benefit to space science and industry.—*PMB*

TV Series on Geophysics

A seven-part public television series on earth sciences, dubbed "Terra Nova," is expected to begin filming this fall. The series, slated for prime time, is also designed as an introductory course in geophysics for college students who are not science majors. Completion of filming is expected in 1985; no air date has been scheduled.

Public television station WQED, Pittsburgh, in association with the National Academy of Sciences (NAS), is producing "Terra Nova." WQED and NAS collaborated on the production of the *Planet Earth* series, which originally aired some 25 years ago. The Annenberg/Corporation for Public Broadcasting (CPB) Project has provided a $3 million grant for "Terra Nova." Two years ago AGU gave $10,000 for NAS to develop basic scientific plans for the geophysics series.

Among the topics to be explored in the series are solar system cosmology, comparative planetology, solid earth geophysics, plate tectonics, mineral resources, hydrology, oceanography, climatology, meteorology, the sun, solar-terrestrial interactions, energy resources, human impact on the earth's environment, and the geologic environment.

To assist WQED in the production of the series, NAS established a blue-ribbon Geophysics Film Committee. Hugh Odishaw, dean of the College of Earth Sciences at the University of Arizona, is the committee's chairman. Other committee members are G. Arthur Barber, Charles L. Drake (AGU President-elect), Herbert Friedman, Laurence M. Gould, Thomas F. Malone, Roger Revelle, Alan H. Shapley, Eugene M. Shoemaker, Walter S. Sullivan, Verner E. Suomi, James A. Van Allen (AGU President), Pembroke J. Hart (committee secretary), John P. Schaefer, and J. Tuzo Wilson (former AGU President). NAS will provide scientific guidance throughout the series' production to ensure the scientific integrity of the films, according to Pembroke Hart.

For college instructional purposes, "Terra Nova" will include an innovative approach to the development of study guide materials, the series' planners say. Computer text processing and laser printing will provide college professors the opportunity to virtually create their own guide materials for the series, which will be divisible into 14 half-hour segments for classroom use or for rebroadcast on a syndicated basis by public television stations after the original prime-time airing in hour-long segments.

"Geophysics has progressed enormously in the past 25 years since *Planet Earth* was produced," said Thomas Skinner, executive vice president of WQED and project director for the new series. "There was no deep ocean exploration then, no space program. This will be the first time anybody has put together all this information on geophysics into usable form. It is a marvelous subject matter to deal with and a chance to produce a landmark."

The Annenberg/CPB Project, funded in 1981 by a $150-million grant from the Annenberg School of Communications, is administered by CPB. Others who have contributed to the financial support of "Terra Nova" are the American Meteorological Society, the Society of Exploration Geophysicists, the Arthur Day Fund, and the Atlantic Richfield Foundation.—*BTR*

New AGU Style Guide

A new, 16-page manual for contributors to AGU publications, called *AGU Style: A Guide for Contributors*, is now available. The guide covers text style and the mechanics of preparing manuscripts for any AGU publication in any format.

To obtain a copy, contact a journal editor or the AGU Publications office, 2000 Florida Avenue, N.W., Washington, D.C. 20009; telephone toll free 800-424-2488 or (D.C. area) 462-6903; or TWX 710-822-9300. Supplies are limited.

Books

Climate History and the Modern World

H. H. Lamb, Methuen, New York, xix + 387 pp., 1982, $38 (hardbound), $16.95 (paper).

Reviewed by William E. Riebsame

H. H. Lamb's latest book on the earth's changing climate is a carefully crafted work covering four areas: the physical basis of climate and climate change, the methods of climate reconstruction, the history of climate since the height of the last glaciation, and the impact of climate on human affairs. The book will be of particular interest to three groups. Atmospheric scientists interested in the long history of climate behavior (but perhaps overwhelmed by Lamb's all-encompassing work on the topic, *Climate: Past, Present and Future*, vol. II, Methuen, New York), will find *Climate History and the Modern World* to be a good iteration of the fuller work. Scientists in other fields, including social scientists grappling with issues of climate-society interaction, will find the book a good entree into the field. Finally, Lamb himself suggests that the book will be useful to resource managers and other decision makers trying to avoid negative climate impacts. With this last audience in mind, no doubt, Lamb has chosen a style that eschews extensive footnoting and references (though sufficient citations are included to lead to further information). This works quite well and seems reasonable in view of his carefully documented previous writings.

Lamb's discussion of basic climatology maintains the connections between individual weather (e.g., extratropical cyclones) and climate elements and the broader issue of climate change. This integration fails, however, in sections on tornadoes and convection. His discussion on causes of climate is excellent (although parts of it are curiously repeated later in the book) for its demonstration of how climate at a point might change owing to instabilities inherent in the climate system without recourse to solar input, volcanic activity, and chemical changes in the atmosphere. When he does discuss these external forces, Lamb clearly delineates their climate role, uncertainty, and potential impacts. Lamb's review of reconstruction techniques is an excellent, parsimonious discussion emphasizing historical sources. It includes a valuable table outlining techniques and their application. Lamb's summary of climate history, comprising slightly over a third of the book, is a compendium of sources, regions, and events that only he could produce. This section can stand alone as a guide for the climate historian, though it may provide too much detail for more casual readers who will probably find more interest in the section on climate impacts.

The climate history ends with 1950, and the subsequent record is incorporated into a discussion of the historical and contemporary socioeconomic role of climate fluctuation. This section is a mix of fact and opinion (facts like harvest failures and opinions on their historical moment). Lamb, like all climate historians, operates in a field of pitfalls related to the sufficiency of proof to implicate climate in past events. Some of his colleagues in the Climate Research Unit at the University of East Anglia, U.K., have recently written on how difficult it is to prove causality in past climate impact studies (M. J. Ingram, G. Farmer, and T. M. L. Wigley, Past climates and their impact on man, A review, in *Climate and History*, edited by T. M. L. Wigley et al., Cambridge University Press, New York). Nevertheless, Lamb's suggested impacts are reasonable, and his insight is a valuable guide to where we might look to refute or support the historical importance of climate change.

Having demonstrated the variability of climate and argued for its important role in human endeavor, Lamb ends the book with suggestions on how we might better cope with climate vagaries. He argues for climate forecasts based on empirical probabilities; indeed, Lamb clearly feels that forecasts based on theoretical atmospheric models may be misleading and bemoans the "disproportionate" research efforts put into computer modeling rather than into a fuller reconstruction of past climate behavior. Unfortunately, his discussion of climate forecasting is not as well organized as the rest of the book, and readers will be confused by the different time scales and approaches touched upon. Additionally, he pays little attention to whether even a correct forecast will be believed and acted upon. If climate forecasts are to help us with the "climate problem," we must know more about their applicability to resource decisions.

Lamb begins and ends the book by claiming that global society is becoming increasingly vulnerable to disruption by climate, a view he supports with Malthusian reasoning. Whether a climate anomaly eventually pushes some segment of global population into a Malthusian disaster or whether we simply continue to experience the hardships reasonably attributable to climate in conjunction with political and social causes, there is no doubt that we must strive to understand climate better. But we should not fall into the trap of doing nothing until we know everything. Lamb's book suggests that we already know a great deal about climate, and it makes this body of knowledge more accessible to a wide range of workers. No doubt, many more lives and much property could be saved by further drawing from this knowledge and our increasing understanding of climate-society interaction.

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Numerical Dating in Stratigraphy, 1 and 2

G. S. Odin (Ed.), Wiley-Interscience, New York, 1982, $134

Reviewed by Marvin A. Lanphere

Geology is a historical science, and geologists always have been fascinated with deciphering complex geologic histories by unraveling the relations of rock units where ages were established by fossils or, more recently, by isotopic dating methods. The most direct way to date stratified rocks is by measuring the ages of authigenic minerals in sedimentary rocks. This approach, however, is fraught with such problems as the presence of detrital minerals, the determination of whether authigenic minerals formed at the same time as accumulation of the sedimentary rocks, and whether suitable minerals for age measurements are present. This new book shows that although there has been significant progress, the problems of directly dating sedimentary rocks by isotopic methods persist.

The book is in two volumes. The larger part of the first volume is devoted to methodology. Subjects that are covered include methods of correlation; isotopic dating methods; and utilization of minerals from sedimentary, volcanic, and plutonic rocks for physical age measurements. The rest of the first volume consists of papers dealing with calibration of the geologic time scale. The second volume contains 251 abstracts based on stratigraphic and isotopic data for critical points on the time scale.

Of the 34 papers in the first volume, 19 are contributions to Project 133 of the International Geological Correlation Program (IGCP) titled "Geochronology of Sediments." Most of the participants in this IGCP project were from European countries, and a primary objective was to establish a radiometric geochronology for the Mesozoic and Tertiary stratotypes in various parts of Europe. Unfortunately, interbedded volcanic rocks are rare, and the principal materials available for physical dating are glauconites, a general term used herein for authigenic green pellets in some sedimentary rocks. (Glauconite, a potassium-rich mica, is a relatively rare, highly-evolved glaucony.) The term "glauciony" has not yet made its way into geological dictionaries. Many of the studies deal with dating glauconies by using the potassium-argon method. Great progress has been made in understanding the mineralogy and evolution of glauconies, but the fact remains that they are less reliable for isotopic dating than are certain minerals in igneous rocks.

I found the part of the first volume on calibration of the geologic time scale to be uneven and disappointing. There were papers on the lower Paleozoic, upper Paleozoic, and Carboniferous; four on the Triassic; and one each on the Jurassic and Cretaceous, the lower Cretaceous-upper Cretaceous boundary, the Paleogene, and glauconiy ages of the southeastern United States.

The second volume is by far the most valuable part of the book. The editor is to be commended for his success in persuading a diverse group of people to compile stratigraphic and analytical data and to present a critical discussion of many of the important time-scale points within a uniform and concise format. This second volume will be a major reference source for many years to come. Most of the abstracts deal with glauconies. Several time-scale points included in earlier compilations (for example, the 1964 Phanerozoic time scale of the Geological Society of London) have been omitted, apparently because the data are on plutonic rocks where stratigraphic age is not precisely fixed. Failure to arrange the abstracts in the second volume in any systematic order is confusing and detracts from their usefulness.

The volumes are well produced, and typographic errors are rare. All references are at the end of the second volume, an arrangement I found a bit inconvenient. In several contributions, the English usage is a bit awkward, apparently because these are by authors whose primary language is not English. The book could have benefited from a more merciless editing by the publisher. Given its cost, this book probably will not be purchased by many other than libraries and geochronologists. If the second volume could be issued separately, I believe it might enjoy wider circulation.

Marvin A. Lanphere is with the U.S. Geological Survey, Menlo Park, CA 94025

Classified

Iowa State University of Science and Technology, Department of Earth Sciences/Research Associate: Electron Microprobe. The Department of Earth Sciences invites applications for a Research Associate position as an electron microprobe specialist. The appointment will be a fully funded, permanent, twelve-month position. Salary will be commensurate with qualifications.

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Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should include a complete resume, a statement of background and interests, copies of publications and names of at least three references. Applications should be sent to:

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Atmospheric Scientist/Arecibo Observatory. The National Astronomy and Ionosphere Center has a staff position available in the atmospheric sciences groups at the Arecibo Observatory in Puerto Rico. It is expected that this will be a long term appointment with the level depending on experience and qualifications. Applicants should have a doctoral degree and a demonstrated ability to pursue an independent research program in the atmospheric sciences. Interest and experience in the remote sensing via radar of the ionosphere or lower atmosphere or in the field of Ionospheric Modification is highly desirable.

The successful applicant will have full access to the facilities of NAIC. For atmospheric research these include the high powered 430 MHz incoherent scatter radar, a bistatic 2380 MHz radar for stratospheric studies, airglow instrumentation and a H.F. Ionospheric Modification facility. A 50 MHz radar intended for MST studies will be available shortly. Scientific staff members at Arecibo have most of their time free to pursue their own research. They are also expected to provide assistance to visiting scientists and support for the Observatory's operation.

Applications including a resume and names for three references should be sent to:

Dr. Tor Hagfors, Director
National Astronomy and Ionosphere Center
Cornell University
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Research Professor in Marine Geoscience/University of Rhode Island. The Graduate School of Oceanography invites applications for a research professorship in Marine Geoscience whose salary and rank are negotiable. Preference will be given to candidates who have clearly demonstrated abilities and interest in, but not necessarily limited to paleomagnetism. The position is funded by contracts and grants, however the research professor holds full faculty rights in addition to other benefits. The paleomagnetic facility at GSO is fully equipped, fully operational and oriented towards rapid measurement of large numbers of soft sedimentary samples. Applications are now open for the position which will become available about January 1, 1984.

Send letters of application, resume, and names and addresses of three professional references to: Roger L. Larson, Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882.

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Visiting Research Scientist Radio Emission Processes

Applications are invited for a visiting research scientist position in the Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa.

This position is intended to support a multidisciplinary study of planetary, solar and astrophysical radio emission processes funded by the NASA innovative research program. Applicants must have a Ph.D. with a good theoretical background in basic plasma physics and experience in either experimental or theoretical studies of planetary, solar or astrophysical radio emissions. Our intention is to favor established scientists with research experience in this area, although junior scientists with an appropriate background will also be considered. The salary will be commensurate with the experience level. The appointment can be for any period up to one year, with a possibility for extension to a second year, depending on funding constraints.

Send curriculum vitae and a list of three references to:

D. A. Gurnett
Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242
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RESEARCH POSITIONS AVAILABLE

The Lunar and Planetary Institute is a center for Planetary and Earth Sciences research associated with NASA programs. The Institute presently has two positions available at the postdoctoral and staff scientist levels. Appointments are initially for one year with the possibility of renewal for additional years.

Areas of current research interest at the Institute include: geophysical analysis of global data sets; planetary geology, including the analysis of surface images and theoretical and experimental studies of impact cratering; terrestrial remote sensing with special reference to volcanic phenomena; planetary tectonics, especially of Mars, Venus and the Earth; and the early crustal genesis of terrestrial planets.

Applications from specialists in all areas of planetary and earth science are invited and will be particularly welcome from researchers whose work augments or complements existing programs.

LPI facilities include a computer center equipped with a VAX 11/780, an image processing facility equipped with a Gould DeAnza IP 8500, a geophysical data facility with interactive graphics capability, extensive library holdings in the geosciences, and a major collection of space photography.

The LPI, funded by NASA through the Universities Space Research Association, is located adjacent to the NASA/Johnson Space Center near Houston. Salary and benefits are competitive and attractive and depend on individual qualifications. Respond before Sept. 30, 1983 to:

Director's Office, LPI
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Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy, The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on theoretical investigations of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer, International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the interpretation of space plasma physics data.

Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

Research Assistant in Ice Core Analysis/Ohio State University. Applications are invited for a position at the Institute of Polar Studies, The Ohio State University, beginning October 1, 1983. Primary duties of the position will include operation and maintenance of the Coulter counters in the class 100 clean room, and processing ice and firn samples. Minimum qualifications are BS degree in physical science or engineering and suitable laboratory experience (or equivalent experience). Please send applications, deadline 1 September 1983, to Director, Institute of Polar Studies, Ohio State University, Columbus, Ohio 43210.

The Ohio State University is an equal opportunity/affirmative action employer.

Geophysicist/University of Saskatchewan. Subject to final budgetary approval, the Department of Geological Sciences will have a new tenurable position in geophysics available July 1, 1984. Applicants should hold, or be about to receive, the Ph.D. or equivalent degree. They will be expected to teach undergraduate and graduate courses in geophysics and to build and maintain a vigorous research program. Excellent research opportunities exist in crustal and exploration seismology and in all fields of mining geophysics. The department, to occupy a new building in 1985, already has well-equipped geophysical and data-processing facilities. Applicants should send a letter outlining their teaching and research goals, accompanied by a full curriculum vitae including the names of at least three referees, to Dr. W. G. E. Caldwell, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada S7N 0W0.

Research Scientist/Stochastic Models of Atmospheric Blocking. A Postdoctoral position for the study of stochastic models of atmospheric blocking is available immediately. Send resume and arrange for three letters of recommendation to be sent to: Professor Katja Lindenberg, Department of Chemistry, B-014, University of California at San Diego, La Jolla, CA 92093.

The University of California is an equal opportunity/affirmative action employer.

GNOC Chair in Mapping, Charting and Geodesy (Hydrography)/Department of Oceanography, Naval Postgraduate School, Monterey, California. Under the sponsorship of the Commander, Naval Oceanography Command (CNOC) a Chair in Mapping, Charting, and Geodesy (MC&G), with emphasis on Hydrography, has been established in the Department of Oceanography, Naval Postgraduate School (NPS). The objective of the Chair is to promote MC&G studies and research by students and faculty, and to encourage acquaintance of the Chair with Navy needs in the MC&G field.

The incumbent's principal responsibilities will be to conduct research and to supervise student thesis research of a type that will interface the Hydrographic Sciences Program of NPS with the MC&G needs of the Navy. A favored theme is research applicable to operational hydrographic survey problems.

Academic excellence and the ability to bring both new ideas are the primary considerations in the selection process. The term of appointment will normally be for twelve month periods (1 October to 25 September); however, exceptions will be considered. Candidates may be members of the academic, federal, or private sectors. Where appropriate, Interagency Personnel Agreements are preferable. For further information, contact Professor G.N.K. Mooers, Chairman, Department of Oceanography, Naval Postgraduate School, Monterey, California 93940, telephone number (408) 646-2673. Send curriculum vitae/resume information and letters of interest to interest to the above address.

The Naval Postgraduate School is an Equal Opportunity/Affirmative Action Employer.

Anticipated Opening/Research Associate. The Coastal Ecology Laboratory Center for Wetland Resources, LSU, has an anticipated opening beginning October 1983. Rank and salary dependent upon qualifications and experience. Ph.D. in coastal hydrodynamics and nutrient transport is preferable. Responsibilities will include development and application of computer models and water quantity and quality aspects, supervising computer programming and preparing technical reports. Background in hydrology, ecology and estuary will be helpful. Experience in statistical, mathematical and numerical analysis is desirable. Send transcript, resume and three letters of recommendation to: Dr. Flora C. Wang, Department of Marine Sciences, Louisiana State University, Baton Rouge, LA 70803 before August 19, 1983.

LSU is an equal opportunity employer.

Chairman—Department of Geological Sciences Wright State University. The Department of Geological Sciences, invites applications for the post of chairman, to be appointed September 1984. We seek a dynamic individual with administrative skills and an appreciation for research and practice-oriented educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435.

Wright State University is an affirmative action equal opportunity employer. Closing date for the position is October 31, 1983.

AGU

Waldo E. Smith Receives First Award of His Namesake Medal

Waldo E. Smith

Citation

This evening marks the first presentation of the American Geophysical Union's Waldo E. Smith Award. While all other AGU awards and honors are given for excellence in scientific research in one or another of the geophysical disciplines, this award is different. The Waldo E. Smith Award is given for dedicated and extraordinary service to geophysics and AGU. It is the principal purpose of this citation to show why it is particularly appropriate that an award for service to American geophysics should be called the Waldo E. Smith Award. A secondary objective, aimed at those present tonight, is to introduce the first recipient of this award, Waldo E. Smith, Executive Director Emeritus of AGU.

Early in 1944, Dr. J. A. Fleming, AGU's General Secretary, approached Waldo with an offer that he become the Union's first full-time Executive Secretary. The Union then had an employee head count of 1¼, with 2000+ members divided into 8 sections—Geodesy, Seismology, Terrestrial Magnetism and Electricity, Hydrology, Meteorology, Oceanography, Volcanology, and Tectonophysics—and was housed in borrowed office space in the attic of the Carnegie Institution Administration Building. On September 22, 1944, Waldo was duly appointed Executive Secretary of AGU, a position which he held until his retirement in 1970 (the position title was changed to that of Executive Director in 1967). The initial appointment was accompanied by Fleming's strong admonition that "Waldo should not concern himself with building an empire." The 1944 AGU auditor's report, reproduced below in toto, recorded the exact physical dimension of the empire that Waldo had agreed to manage.

Equipment owned by the American Geophysical Union

One 18-inch primer Burroughs typewriter, ser. No. 60A232450	$190.80
One 10-inch elite Royal typewriter, ser. No. KHM-2076351	$100.31
Two 4-drawer, 5×8-inch steel filing cases (gift)	$ 0.00
Two steel posture chairs	$ 22.00
One Globe-Wernicke, 2-pedestal flat-top steel desk, 60×34-inch	$ 49.18
One Triner postal scale, 4 lbs. by 1/2 oz.	$ 16.20
One Arrow stapler	$ 6.75
	$385.24

Using the above as a base, Waldo went to work, and hard work it was by all accounts. For the next 25 years Waldo continued to build AGU, and by the time of his retirement AGU existed largely in its present form and substance. Consider Figure 1 where the growth in AGU statistics for the Waldo era has been plotted. During his tenure the Union grew from 2000+ to 10,000+ members, the staff grew from 2½ to 40 full-time paid employees, and the journal pages published per year expanded from 482 in 1945 to 17,032 in 1970.

But rather than just considering the numbers of Figure 1 let us translate some of them into entities, and see just what these statistics have actually meant to American geophysics.

In 1959 the *Journal of Geophysical Research* (JGR) was incorporated into AGU. (Previously, JGR was an unofficial publication of the Carnegie Institute). Phillip H. Abelson and J. A. Peoples, Jr., were the first JGR/AGU editors. In its first year under the AGU masthead, with the help of an NSF grant, JGR published 2460 pages; by 1962 this count had risen to 5398; and by 1970 to 7656.

Water Resources Research first appeared as a quarterly in 1965 with Walter B. Langbein as editor and with a total page count of 586; by 1970 this count had risen to 1806 pages with bimonthly issues and was well on its way to being the premier research journal for water.

Reviews of Geophysics first appeared in 1963, with Gordon J. F. MacDonald as editor. As a matter of policy the number of pages published by this journal has always been a fairly tightly restricted percentage of the number of pages in JGR, but nevertheless Reviews likewise grew from 665 pages in its first year to 864 in 1970 (by which time it was called *Reviews of Geophyscics and Space Physics*).

Further, it was in the Waldo era that AGU's journal translation program started. First came the journals of *Izvestiya, Academy of Sciences, USSR* (*Physics of the Solid Earth* and *Atmospheric and Oceanic Physics*—IZVE/IZVA) in 1957, but by 1965 the number of translation journals being published by AGU had risen to seven. Similar success sagas are associated with AGU's books and monograph series, and all can be said to owe their existence to the friendly environment created for them by Waldo E. Smith. AGU journals and books are highly respected throughout the scientific community, and they are still one of the few real bargains existing in the scientific literature.

Keep in mind that this highly successful publication program was accompanied and orchestrated from 1944 to 1970 by the omnipresent Waldo E. Smith, who acted in this period (depending upon one's point of view) as either the midwife or as the despot, but in any case as the one who always managed to see to it that what had to be done to assure success was indeed done.

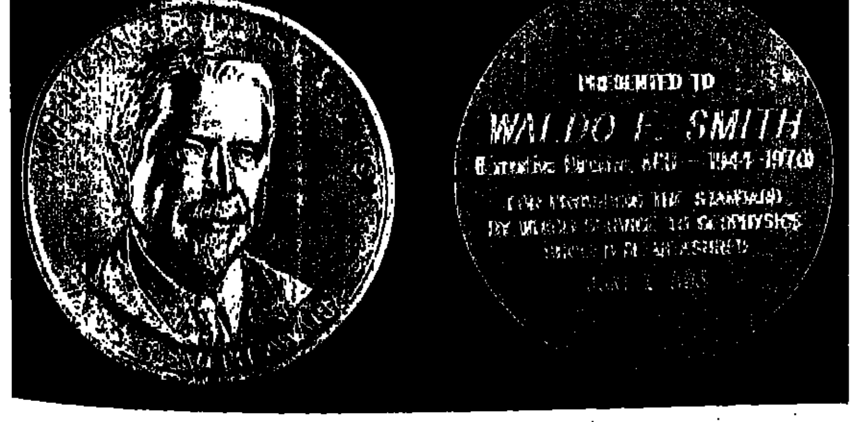
In addition to the above list of obvious, major accomplishments, AGU has benefited from some of Waldo's lesser known political and personal abilities. For instance, on October 4, 1957, "Sputnik" appeared, and with it a new, enhanced interest in the science of space. The AGU Council was split on whether or not "space" could be considered as geophysics, but in the end Waldo's pragmatic view "that geophysics is whatever we say it is" prevailed, and by a majority of one vote the Council allowed for the formation of a Section of Planetary Sciences. Dr. J. A. Van Allen served as the first Section President for the new section.

Further, in spite of all the growth and activity that surrounded Waldo he never forgot that AGU was its members. It is reputed that he knew all the members by name, by sight, and by scientific interest. This must be an exaggeration, but I do know that in my own case I met Waldo very soon after joining the Union because he took the trouble to introduce himself to me at the very first meeting that I attended. Subsequently he never forgot my name, or for that matter the subject of our original conversation. In this regard, I do not believe that I received special treatment, and in fact while researching this citation I received many confirmations of this beloved, ego-boosting ability which Waldo used upon the membership.

However, let us be fair; I did uncover one instance of fallibility. Like a good coach, Waldo always addressed staff members by their last names, and like AGU member names, once learnt these were never forgotten. However, one employee, Miss Chamberlin, married and changed her name. Waldo knew this, but his usually faultless memory-banks exhibited a defect. For 2 years Waldo never addressed that staff member. But the story does have a happy ending, because eventually Helmut Landsberg did manage to teach Waldo how to pronounce Holovink, and communication was restored.

But let us return to the business at hand. AGU now has 15,080 members, of whom 65.56 percent joined the Union after Waldo E. Smith's retirement. The AGU staff now numbers nearly 70 of whom only a handful have tenures that date back to the Waldo E. Smith era. AGU's annual publication revenues now total $5,900,000. We are housed in our own building, and our annual meetings produce presentations that number into the thousands. In summation, when Waldo E. Smith retired in 1970 he left the Union as a vibrant, growing organization.

AGU (cont. on p. 464)



Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; who is a leader in ocean engineering, technology, and instrumentation; or who has given distinguished service to the marine sciences.

Robert E. Horton Medal. Given for outstanding contributions to the geophysical aspects of Hydrology.

James B. Macelwane Awards. Up to three awards are given each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal* - Eugene M. Shoemaker, U.S. Geological Survey, 2255 Gemini Drive, Flagstaff, AZ 86001; *Ewing Medal* - Robert O. Reid, Department of Oceanography, Texas A&M University, College Station, TX 77843; *Horton Medal* - R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; *Macelwane Award* - J. Freeman Gilbert, IGPP A-025, University of California/San Diego, La Jolla, CA 92093.

Deadline for Nominations is November 1, 1983.

Nominations for 1984 AGU Fellows

Nominations for Fellowship in the Union are being sought by the Fellows Committee and the Section Selection Committees. Nominees for Fellowship should be scientists who have attained acknowledged eminence in a branch of geophysics. The total number of Fellows elected each year cannot exceed 0.1% of the total membership.

To be considered by the Committee, nominations for Fellowship in AGU *must be made on the form below. If more space is needed, attach a separate sheet.*

AMERICAN GEOPHYSICAL UNION
Nomination For Fellowship

Name of Nominee ____________ Name of Sponsor ____________

Personal Data on Nominee

Business Address (including Position held) ____________

Date and Place of Birth ____________

Education (degrees, institutions, major field) ____________

Professional Record (including special honors) ____________

Membership in other Scientific Organizations ____________

Attach a list of most significant publications (not abstracts, book reviews or papers which have not yet been accepted for publication).

Sponsors Evaluation of Nominee

Attach a supporting statement which must include: (1) An indication of the length and nature of your acquaintance with the nominee; (2) the Nominee's contributions to the field to date; (3) your evaluation of the nominee's scientific ability; (4) a one-line citation, "For . . . .", summarizing why the nominee should be elected a fellow.

Signed ____________ Date ____________

Sponsor's Title and Affiliation ____________

For a list of current Fellows, call or write AGU.

Send nominations for forwarding to the appropriate Section Selection Committee to:

AGU Member Programs
2000 Florida Avenue, N.W.
Washington, D.C. 20009
Telephone toll free 800/424-2488
or 462-6903 in the Washington area

Deadline: September 19, 1983

AGU (cont. from p. 463)

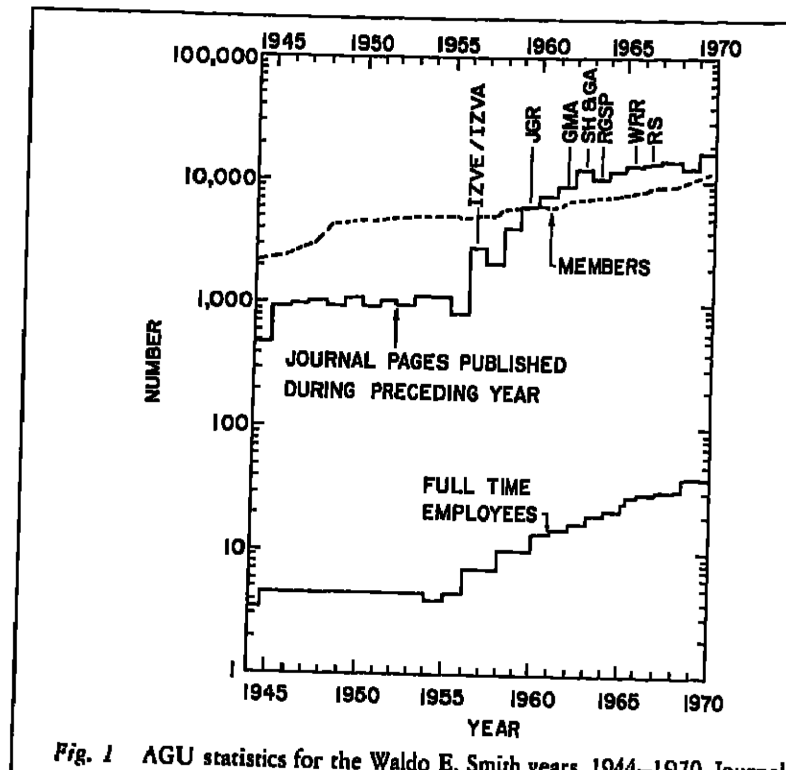


Fig. 1 AGU statistics for the Waldo E. Smith years, 1944–1970. Journal pages published are raw data totaled without regard for varying page sizes.

The 1982 AGU Council formally recognized the adage "that there is more to doing science than doing science" when it established an award in recognition of dedicated and extraordinary service to geophysics. The award, which includes a medal, is to be given no more frequently than every other year. It is most appropriate that these medals to be given by AGU for service to geophysics should bear the likeness of Waldo E. Smith upon one side of them, because for over a quarter of a century AGU, American geophysics, and Waldo E. Smith were synonymous.

Like William Bowie, who received the first Bowie Medal, Waldo E. Smith is present to receive the first of the medals that bears both his name and his portrait. For service to AGU and to geophysics, Waldo E. Smith has provided the measure and the standard by which all who would follow must be judged. It is with pleasure and with some sense of poetic justice that I now turn to our current AGU President, Dr. J. A. Van Allen, and ask him to make the formal presentation of AGU's newest award, the Waldo E. Smith Award for outstanding service to geophysics.

James R. Wallis

Acceptance

As I stand here before you, I feel both very humble and very honored. It would seem that an executive officer of such an organization as the AGU gets much credit that he does not deserve: this success not only from his staff, but even more largely from the work of competent devoted officers, committee chairmen and members, and the membership as a whole. It is through them that the executive's efforts are meaningful. I recall that back in 1945 when I arranged my first annual meeting. During the war years, we had to receive permission from some wartime government agency to hold such a meeting. This was not difficult; earth sciences were already recognized as important to the war effort. The section secretaries and their committees did a creditable job of arranging a good program. Then I had a strange feeling in the pit of my stomach: What if no one but the speakers came? I think that the record will show that some 800 or more came. And I had a feeling of elation as the meeting drew to a close that the meeting had been a success. Thus it was, after every succeeding annual meeting.

But there were other problems. AGU was started by the National Academy of Sciences—National Research Council in 1919 as the U.S. National Committee of the International Union of Geodesy and Geophysics organized by the International Research Council (now ICSU). Originally it had 65 members appointed to cover what was then deemed to span geophysics. During the 1920's, the number was increased to 75, then 100, then 200, and after the financial crash of 1928, the limit was eliminated and most anybody who was willing to contribute $2 per year was taken into membership. The annual reports and papers presented at the meetings had been published in the NRC series, but after the crash, the NRC cut back on its publishing program and gave the AGU $400 annually, which with the $2 contributions from the members, growing slowly in number, gave a small working fund.

That was the point that the ingenuity of Dr. John A. Fleming who served as General Secretary of AGU from 1925 until 1947 (and then became Honorary President for Life) came into the picture. He pioneered in the preparation of master copy by typewriter with reproduction by offset which continued into the 1950's, effectively using the limited funds available. The *Transactions* came out each year, usually in two or more parts. In 1945, when I came into the picture, the *Transactions* became a bimonthly. These old annual volumes contain many papers deemed to be classics and are very choice. Free copies were sent to all members who had contributed and to some 800 libraries without charge.

I never quite heard why or how I became the first executive officer. Dr. Fleming was my mentor, a relationship of which I am still very proud. There was a call for candidates, a selection committee functioned, but in the end, Dr. Fleming made the selection. It was not with rancor, but with real admiration that the organization was sometimes referred to as the John A. Fleming Geophysical Union. He bore a heavy load of work as a volunteer, a devoted volunteer, for over 20 years, editing, corresponding: the prime mover. And he was a perennial optimist, especially with respect to geophysics and most especially the AGU. But the burden became too great, and the membership had grown to about 2,200. He and other officers had sought and received the promise of a grant of $20,000 over a three-year period from the Rockefeller Foundation to establish a full-time secretariat, on the condition that another $10,000 be raised by the membership. So, at the outset, the annual receipts from the membership was 2,200 x 2, or $4,400. About 90 percent of the libraries subscribed. There was lengthy discussion whether the membership would accept a 50 percent increase in dues, from $2 to $3. Academic geophysics had a very limited constituency. Would we lose 90%? Or 50%? Or very few? The loss, as I recall, was about a normal 2%. Freeborn Johnston, a member of Dr. Fleming's terrestrial magnetism staff, was membership chairman, and in a bit over a year, he sent out some 15,000 personal notes to prospective members; that brought in some 1,500 new members. And so AGU, always financially poor, struggled on.

Then along came the IGY. Early in the 1950's, our incumbent president, Dr. Van Allen, and some of his colleagues felt that a third International Polar Year (following the first in 1882–83 and the second in 1932–33) might be in order and named it the International Geophysical Year (IGY). This idea met with enthusiasm abroad, and plans were furthered at the Rome meeting of the IUGG in 1954. The IGY became a phenomenal success.

Celebrating the 25th anniversary of the IGY at the recent meeting of the NAS, President Frank Press (formerly president of AGU) expressed the idea that this IGY endeavor might truly be unique. It was based on the long developing idea that it was necessary that the earth as a whole should be given serious attention. Dr. Herbert Friedman of the Naval Research Laboratory presented a paper, "The Legacy of the IGY (One Hundred Years of International Cooperation)." There had been the growing feeling throughout the years that the interrelationships in geophysics transcended any one field. Friedman noted that Lieut. Karl Weyprecht of Austria, in the 1870's, proposed what became the First International Polar Year (1882–83) that drew geophysicists together.

Now, coming back to the 1954 IUGG Rome meeting: Clare Boothe Luce was the U.S. Ambassador to Rome. An American reception was held in an embassy home. It was my pleasant duty and honor to present the various foreign delegates to her. From that time on, it seemed to me that *Time* gave frequent favorable word concerning the IGY effort.

A quarterly, *Terrestrial Magnetism and Atmospheric Electricity*, had been privately published by the director of terrestrial magnetism of The Carnegie Institution of Washington, and Dr. Fleming had that under his wing also. When Dr. Merle Tuve became the director of quarterly, he changed its name to the *Journal of Geophysical Research* (JGR) and in 1959 turned this title and the quarterly's good will over to AGU. With the aid of NSF grants, AGU issued JGR monthly, then semimonthly, and then, as now, three issues a month. Books resulting from the IGY work also needed publishing, and there was need to know more about what was going on in geophysics in the USSR. The NSF gave us grants to translate their best geophysical journals. New journals were started, as noted by Dr. Wallis. At last geophysics had a real and growing constituency. Each year we were able to save a bit, and we established a reserve fund. It had been my hope that a reserve equal to a year's budget might be developed, but during the closing years of my incumbency we got up to 1/3 of the annual budget, and I think that that is about the present ratio. Of course, as the budget went up, due to inflation and for other reasons, the amount increased.

Inflation struck with full force just after I retired in 1970, and presented a new set of problems to the officers and to my successor which I think were met very well, but I would like to see that reserve ratio increase and a distinct reserve fund established, not for normal operating purposes but to meet new opportunities and challenges. It was on this basis that I have joined the volunteer effort to raise such a fund. You have received appeals regarding this effort from time to time and there has been considerable response. But it is a long hard pull. Earlier we missed opportunities, and other groups have filled some of those gaps, tending to disunite efforts toward the integration of a continuing broad unity in geophysics.

Dr. Wallis told you about the critical moment when the motion adopting Dr. Van Allen's report to have AGU embrace the environment of the earth in space won by a single vote. It gave me that earlier, sinking feeling again that I got at the time of that first annual meeting: What would AGU be like today if that one vote had gone the other way?

It has not been all smooth sailing, as some of you younger members may feel in the present situation. AGU is no longer poor financially, but neither is it wealthy. AGU has no endowment and has not been in a position to establish a foundation. Meeting current needs has always been a real challenge. We need faith and hard work to have the joy of success. Dr. Wallis just told you that two-thirds of the membership today became members since I retired in 1970. I look at attendees of our meetings, and I find many bright young faces. This bodes well for the future. Challenges will continue: may you carry on in the traditions of the past to an even greater future.

A lot more could be said, but those critical years were pretty well chronicled in the *Transactions* of 1964 (pp. 1 to 47). See if your librarian can dig the issue out.

One regret that I feel today is that my faithful Martha, my lovely lady for 55 years, could not have been here tonight to share this moment of joy with me. But I am glad that my daughter, Carol, could fly up from Richmond this afternoon to be here.

Thank you.

Waldo E. Smith

Meetings

Announcements

Environmental Biogeochemistry

On October 9–15, 1983, Santa Fe, N.M., will host the Sixth International Symposium on Environmental Biogeochemistry. As a forum for biologists, chemists, and geologists, the symposium will deal with topics ranging from biological evolution to observations of microbes living in the cracks of stones found in the Antarctic. Microbes living in groundwater, a subject that has not been given much attention, was added recently to the agenda.

On October 8, preceding the first symposium sessions, various field trips will be offered to the Carlsbad Caverns, the Kennecott Chino Mine, Sangre de Cristo Mountains, and the Jemez Springs.

Contact James A. Brierley, Department of Biology, New Mexico Institute of Mining and Technology, Socorro, NM 87801, for more information.

Climate and Environment

Changing climate and its effects on agriculture and environmental quality will be the subject of the 12th Annual Conference of the Illinois Department of Energy and Natural Resources to be held September 13–14, 1983, at the University of Illinois at Urbana. The conference, entitled "Illinois Climate: Trends, Impacts, and Issues," will deal with such topics as acid rain, the effects of increasing carbon dioxide in the atmosphere, and the relationship of agricultural pests to weather and climate.

For more information contact Mae Maxwell at the Office of Conferences and Institutes, University of Illinois, Urbana, IL 61801(telephone: 217-333-2883).

Space and Climate Conference

As part of its biennial meeting, June 25 to July 7, 1984, in Graz, Austria, the Committee on Space Research (COSPAR) of the World Climate Program (WCP) is organizing a special Symposium on Space Observations for Climate Studies. One of the largest scientific projects of the current century, the WCP is both international and interdisciplinary in scope.

Recognizing that the key component of the WCP's observational program will be based on satellite measurements, the symposium will focus on the current observational requirements of the program, on results and interpretations of recent observations, and on future observational requirements.

Invited and contributed papers will cover such topics as basic atmospheric variables (temperature, pressure, humidity, winds, and precipitation), clouds, the earth's radiation budget, the oceans, the cryosphere, land and surface hydrology, detection of climatic change, and space data (requirements, management, and international coordination). In a special opening session, scientific leaders of the World Climate Research, Impact, Applications, and Data programs will provide a summary of the current status and data requirements for these programs. The proceedings of the symposium will be published.

For further information contact S. Ruttenberg, Secretary, COSPAR Commission A, NCAR, Boulder, CO 80307.

Cosponsors of the symposium include the World Meteorological Organization, the International Association of Meteorology and Atmospheric Physics, the United Nations Environment Program's Scientific Committee on Oceanic Research, the International Union of Radio Science, and the Scientific Committee on Antarctic Research.

Meeting Report

1983 AGU Spring Meeting Report

Attendees at AGU's 1983 Spring Meeting once again found Baltimore to be a very hospitable, convenient, and delightful place and the Convention Center to be an excellent meeting facility. There were 2100 attendees, and 1400 papers were presented. Changes to the program and additional, late, and revised abstracts are printed below.

Papers Not Presented

U32–01A, R. K. Cormick.

A12–07, W. L. Flowers et al.; A12–12, P. Aharon.

GP11–01, D. L. Lin; GP11–02, P. H. Moose et al.; GP12–14, B. G. Thompson; GP21–04, C. E. Barton; GP22–10, R. J. Johnson et al.

H11–01, S. R. Kshirsagar et al.; H21–05, D. S. Finan et al.; H22–01, P. Blaszczyk; H22–01, S. Rasmaseshan; H31B-16, S. T. Kim.

O11A-08, J. D. Hawkins et al.; O31–05, D. J. Fornari et al.; O32A-06, F. C. Newman et al.; O32A-07A, J. R. Schubel; O32A-07B, W. F. Bohlen; O32B-05, M. R. Carnes; O41A-09, R. Ahmad et al.; O42A-10, K. Kim et al.; O51B-14, R. G. Ingram.

S11B-05, B. Valez et al.; S12–05, C. Lemesle et al.; S32–04, T. R. Visvanathan; S42-01, S. M. Day et al.; S42–02, I. R. Sampwitz et al.; S42–05, J. P. Todoeschuck et al.; S51-03, J. D. Phillips et al..

SA51–05, W. Swider; SA51–06, B. J. Watkins et al.

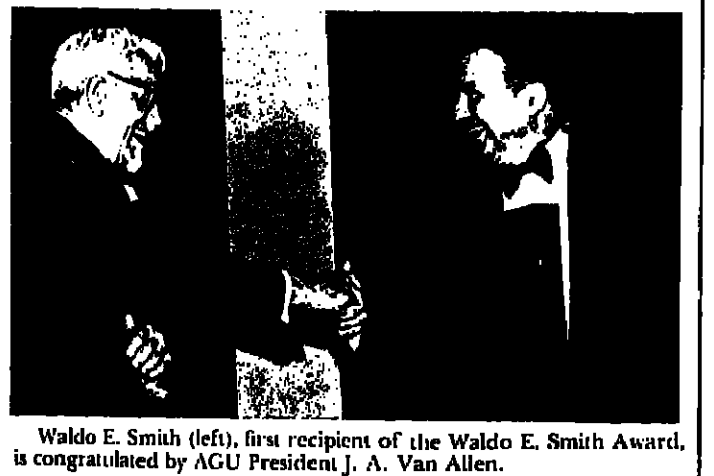
SM22E-22, W. A. Kolasinski et al.; SM41B-03, J. F. Fennell et al.

SS22–08, J. A. McKinnon et al.; SS42-03, L. D. Smith et al.

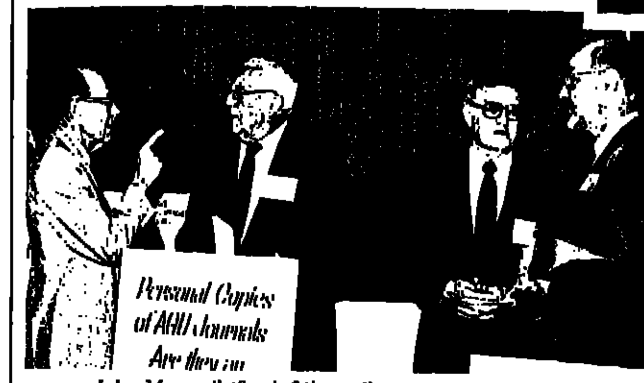
T22A-01, M. C. Roufosse; T32–09, A. Schedl; T51–03, R. K. O'Nions et al.; T51-06, F. M. Richter.

V11A-12, D. C. Noble; V12A-05, L. M. Le Bel et al.; V22A-02, K. T. M. Johnson et al.; V31B-06, J. W. Prescott et al.; V32A-08, W. H. Zoller et al.; V32A-09, D. L. Finnegan et al.; V42B-01, J. F. Stebbins et al.

Newly elected AGU Fellows receive their certificates from AGU President J. A. Van Allen.



Waldo E. Smith (left), first recipient of the Waldo E. Smith Award, is congratulated by AGU President J. A. Van Allen.



John Maxwell (far left) enrolls as an AGU Individual Supporting Member with AGU Gift Steering Committee members (left to right) Charles Whitten, Earl Droessler, and Morton Rubin.

Panelists at the Union session on Verification of Nuclear Test Ban Treaties answer questions from the audience.

Late and Revised Abstracts

Union

U32-01A INVITED

Satellite Data and Geology

DONALD K. CORMICK (Conoco Inc., P.O. Box 4800, The Woodlands, TX 77380)
(Sponsor: Frank Eden)

Earth scientists recognize the benefit of different perspectives when studying features of varying scales. We have accessed every technological advancement to "see the woods for the trees" or, in our terms, "the mountains for the outcrop." Today, we call it the "synoptic viewpoint." We have progressed through photography from mountaintops, hot air balloons, airplanes, rockets and even the Skylab satellite to multispectral digital images from high-altitude orbiting satellites. Throughout this revolutionary period we have experimented with many different sensors as well as several sources besides the sun.

The fundamental influence of satellites on the earth sciences comes precisely from our original objective--obtaining a better synoptic view! The most important secondary benefits accrued from better spatial resolution (detail on the ground) and better spectral resolution ("seeing" features outside our normal visible wave length range). Recently, we also have benefited from airborne and space-born systems that penetrate the earth's surface and detect information in the third dimension that geologists can't discern.

In this paper we will briefly review the earth science-related information provided by the many, varied civilian satellites that have successfully orbited the earth. We will discuss the uses made of such information, estimating its impact in each major application area.

There are inherent limitations in the accuracy of all remotely-sensed data, and in the ultimate value of such information to any earth scientist. Sometimes these limitations are overlooked and/or understated. Depending on who is involved, this can hurt the credibility of a report, a scientist, and even the technology. We will look at some of the most critical limitations, speculate on the likelihood of overcoming or at least diminishing them, and then discuss the credibility issues that have evolved.

Finally, as all successful explorers indulge in risky ventures, I will extrapolate from the present into the future and predict the influence of satellites on our science in 10 to 30 years. The affect of the sad disarray of this nation's civilian satellite program will be blunted by the relatively aggressive programs in Japan, France, and elsewhere.

Geodesy

G31-12A

Gravsat Simulations for Analysis of Geopotential

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Computer simulation results for the Geopotential Research Mission (formerly Gravsat) have been obtained which support accuracy goals of the mission, namely 3 mgals for gravity anomaly and 10 cm for geoid height with a half-wavelength resolution of 1 degree. The computer simulations were performed with satellite-to-satellite doppler tracking (±1 micron/sec) between two low altitude satellites at 160 km in polar orbits and separated by 100 km in a drag-free environment for a 4-month mission lifetime. Results from studies have been obtained as follows: (1) the recovery of spherical harmonics with potential coefficients complete through degree and order 36 gave an accuracy of 2 to 3 orders of magnitude better than current knowledge; (2) recovery of geoid height and gravity anomaly in a local region (30° LAT x 20° LONG) in the presence of unmodeled errors external to the region gave an accuracy of 7 cm for geoid height and 4 mgal for the gravity anomaly for 1° x 1° blocks within the interior of the region; (3) the recovery of 1/2° x 1/2° blocks of geoid height and gravity anomaly in a local area containing a trench region gave, with use of eigenvalue analysis, commission errors of 3 cm for geoid height and 3 mgal for gravity anomaly for 1° x 1° block size; and (4) a Fourier analysis over the trench region in (3) confirmed the results of this study which satisfy accuracy goals of GRM. The study under (1) has shown that analysis is needed to extend the spherical harmonics to high degree (70 to 100) to reduce a significant aliasing effect on the solution due to the truncation of the harmonics. Also, because of the need for computer time efficiency in a global simulation, the technique of deriving the potential first at satellite altitude and then downward continuing the result to the surface of the earth is being investigated.

G42-12A

Multi-Tone Phase Extraction in VLBI System Calibration

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(Sponsor : Jan Kouba)

The precise geophysical applications of VLBI require careful calibration of the phase delay of the receiving system. This calibration is normally achieved by injecting a pulse train into the received astronomical signal and then detecting the phase of the Fourier components of the pulse train which lie within the VLBI passband. VLBI applications requiring detailed phase information about the passband or precise knowledge of the single channel group delay require the simultaneous detection of a number of these tones. In the case of the Canadian Geophysical LBI System (C2) currently under development, a single 24 Mhz channel (12 Mhz USB/12 Mhz LSB) is used to sequentially sample the IF band. If compatibility with the Mark III VLBI System is desired at the IF level, at least 10 calibrator tones will occupy each of the bands. Under these conditions the detection of the phase of these tones using separate phase detectors would be uneconomical. An alternate approach is proposed. This alternate method requires that the data sampling rate and frequency at the edge of the VLBI passband be integer multiples of the calibrating pulse repetition rate. Under these conditions, the baseband calibrating signal also repeats at the pulse repetition rate and hence it can be averaged. This averaged periodic waveform, being the impulse response of the VLBI system as sampled by the calibrating pulse train, can thus be used to determine the necessary phase information for all tones within the passband.

G42-12B

Tilt at Pinon Flat Observatory, California.

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D.D. Jackson (IGPP, UCLA, Los Angeles, CA 90024)

We are operating three 535 meter fluid tiltmeters and a 25 m deep borehole tiltmeter side-by-side at Pinon Flat Observatory, CA. In addition, we have installed leveling benchmarks in a 2500 m loop that includes the tiltmeter baseline. We surveyed parts of the loop ten times, and the entire loop five times since Oct. 1978.

We hope to observe aseismic tectonic tilting on one or more tiltmeters with reasonable agreement. We have not yet achieved this goal, but we have learned much about tilt measurements. The tiltmeters agree well at tidal periods (to within a few percent), but not so well at longer periods. During the period 21 Oct 81 through 27 Mar 82, the apparent drift rates ranged from 0.2 to 4 microradians per year. One of the tiltmeters suffered from large temperature effects. Recent improvements should reduce the drift rates of some of the instruments. Data collected since 27 Mar 82 appear comparable to the previous data, except that heavy rainfall caused obvious transients.

Random benchmark motions of up to 1 mm cause the dominant errors in the leveling data. Therefore, we established several special benchmarks anchored at about 10 m depth. Using these monuments, we can estimate the tilt rate to within about 0.5 microradian per year.

G51-12A

Geoid Anomalies over the Macquarie Ridge Complex Indicate an Unexpected Subducted Slab

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ANNY CAZENAVE (CNES-GRGS, 18 Ave. Edouard Belin, Toulouse, 31055, France)

The boundary between the Pacific and Indian plates is presumably coincident with the seismically active Macquarie Ridge complex (hereafter: MRC), which lies between South Island (New Zealand) and the Pacific spreading center. Along the nearly north striking MRC, the RM2 relative plate velocity model (Minster & Jordan, 1978, JGR, 83: 5331) predicts oblique convergence in the north, grading into strike-slip motion in the south. The focal mechanisms of the large recent earthquakes along the MRC are consistent with the RM2 model. It is therefore puzzling that the physiographic expression of the southernmost MRC is the Hjort trench; a trough 500 km long that reaches a depth greater than 6 km as compared to the 3.6 km depth of the surrounding seafloor. Plate tectonic reconstructions of the southern Pacific indicate that the Hjort trench region has never been a convergent plate margin. As small troughs do occur along large fracture zones, can we assume that the Hjort trench is a strike-slip feature? We employ geoid anomalies, obtained from SEASAT radar altimetry data, to address this question. Previous studies have shown that high-resolution geoid profiles across subduction zones and fracture zones are distinctly different. Therefore, observed geoid anomalies will help discern the nature of the MRC plate boundary. Our main result is that the geoid anomalies associated with the northernmost Hjort trench have the characteristic shape and wavelength of subduction zone anomalies. These geoid anomalies can be explained by a subducted slab dipping to the east. This interpretation requires that the plate tectonic models for this region be reassessed. The motions in the MRC region may not have followed those of the two large adjacent plates.

Hydrology

H42-04A

Assessment of Uncertainty of Fracture Flow Simulation Utilizing A Simple Extension of The Equivalent Porous Media Concept

James Tracy (Ertec Western, Inc. Long Beach, CA 90807)
Michael Teubner (Ertec Western, Inc. Long Beach, CA 90807)

A simple equivalent porous media model is proposed and utilized to investigate the uncertainty of fracture flow analyses. The proposed model is a simple extension of the equivalent porous media concept. The analyses address the problems the uncertainty of fracture flow parameters, the definition of fracture geometry, and the definition of primary-fractured connectivity that are required to perform fracture flow analyses.

The [illegible] is utilized to estimate the range of uncertainty in the aggregate media and the implications on transport in a fracture media. The model is, however, limited in utility by the simplicity of its formulation.

Ocean Sciences

O12A-09A INVITED

SAR Measurement of Wave Fields with Multiple Directional Components: Observations & Comparison

John F. Vesecky, Martha P. Smith and David J. Napolitano (Stanford Center for Radar Astronomy, Stanford, CA 94305)

Measurement of ocean wave directional distributions is difficult since pitch-roll buoys provide only crude directional information and wave-rider buoys, no directional information at all. Arrays can provide directional information, but are difficult to deploy. Synthetic aperture radar (SAR) images of ocean wave fields can be used to sense wave directional distributions, but the technique has important limitations. We explore the ability of SAR to measure wave directional distributions using digitally processed images of waves near the Island of Foula (SW of the Shetland Islands). The image contains wavefields with a single dominant component and with multiple directional components generated by refraction and diffraction near the island. We compute normalized 2-dimensional spectra of pertinent images to address two issues. First, how well can SAR sense wave systems with multiple directional components? Second, how well does current SAR theory of ocean wave imaging describe the degradation of SAR resolution for wave fields with multiple directional components? We compare experimental results with the theoretical predictions of Alpers, Ross & Rufenach and of Jain, who addresses the multiple component case specifically.

O21-12A

Sea Level and Circulation

Keith R. Thompson (Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1)

Sea level and transport variability off the North Atlantic are examined in the frequency range 6.00 - 0.04 cpy (1950-1975). The sea level data were recorded at 61 mainland and island stations (64N - 18N). The Sverdrup transports are determined from monthly wind stress distribution.

Each sea level series is corrected for the influence of local air pressure and local wind stress. A coherent sea level variation is found along the eastern boundary of the North Atlantic from Newlyn (50N) to Tenerife (28N). Along the east coast of the United States and Canada there are two distinct regions of sea level variability, separated by Cape Hatteras. The variations north of Cape Hatteras are coherent with those along the eastern boundary.

Variability of the total meridional Sverdrup transport across selected latitude circles is shown to increase northward. The power spectra are less red than the sea level spectra. The frequency dependent response of North Atlantic sea level to transport fluctuation is finally discussed.

O32A-07A INVITED

The Estuary As A Filter: An Overview

J. R. SCHUBEL (Marine Sciences Research Center, State University of New York, Stony Brook, N.Y. 11794)
(Sponsor: N. J. Bowman)

I review the processes that characterize the estuary and describe how they cause the estuary to function as a filter for the signals it receives from the land and from the sea. Tidal currents provide energy for mixing saltwater from the ocean with freshwater from the river. The resulting salinity distribution drives the non-tidal estuarine circulation, which in turn redistributes the salinity. This feedback between salinity redistribution and gravitational circulation places a constraint (filter) on the range of variation in flow and salt concentration in the estuary. The non-tidal estuarine circulation also controls the distribution and transportation of suspended sediment, and the deposition of fine particles within the estuary. The distributions of salt and fine suspended matter control the behavior of many non-conservative constituents: their modes of occurrence, transport, and their reservoirs of accumulation. The result of these processes is that the estuary modifies significantly the strength and the form of the chemical and geological signals it receives. Alteration of an estuary's non-tidal circulation pattern by changing its freshwater input or its geometry produce changes in its filtering efficiency. In general, as an estuary moves from a highly stratified estuary toward a well-mixed estuary, its filtering efficiency for land-derived constituents first increases to a maximum for partially-mixed estuaries and then decreases.

O32A-07B INVITED

Aspects of Storm Induced Sediment Resuspension in Coastal Waters: A Review

W.FRANK BOHLEN (University of Connecticut, Marine Sciences Department, Avery Point, Groton,Ct. 06340)

The passage of high energy storm events has the potential to affect sediment resuspension in coastal and estuarine waters. Resuspension magnitude and associated mass flux varies as a function of local hydrography and sediment characteristics, basin orientation and morphology, and storm quality. This latter factor depends on storm duration, wind stress intensity, dominant wind direction and the speed and direction of storm advance. Historically studies of this multivariate problem have used a lumped parameter approach in which sediment displacements were simply related to storm occurrence without concern for specification of the particular factors dominating cause and effect. The approach provided little information on governing dynamics. Recently improved understanding of two-phase dynamics within the benthic boundary layer and the availability of reliable instrumentation has permitted initiation of field studies of storm resuspension. These studies indicate that storm induced resuspension is typically short-lived and confined to the storm period. This rapid deposition implies settling velocities well in excess of those inferred assuming Stoke's settling. Beyond the short-lived nature of storm resuspension the field data indicate a high degree of spatial and temporal variability in dominating factors. In open continental shelf waters resuspension is dominated by surface waves and associated interactions with local tidal currents. Resuspension magnitude is governed primarily by storm duration and intensity and is relatively insensitive to storm track. Proceeding inshore magnitude becomes progressively more sensitive to dominant wind direction as coastline orientation affects fetch and the intensity of wind/wave induced currents relative to the tidal stream. Associated temporal variability increases due to biologically mediated sediment stabilization and/or destabilization. The field data permit simple modelling of storm resuspension and serve to define areas needing additional research.

Planetology

P12-06A

Transit Time from Mars to Earth

G. W. WETHERILL (DTM, Carnegie Institution of Washington, Washington, D.C. 20015)

Impact experiments and theories suggest that small (< 1m) fragments are those most likely to escape Mars. If SNC meteorites represent such small ejected fragments, their transit time to Earth must be ≲10 m.y., as indicated by their cosmic ray exposure ages. Valid calculations of "Mars-crossing" transit times have been previously presented only for initial asteroid-like orbits with perihelion near Mars. These calculated times of ≳100 m.y. are not consistent with the observed SNC exposure ages and with the survival of small stony meteorites in the asteroid belt.

Transit times have now been calculated for material ejected at random positions in Mars' orbit at ejection velocities ranging from Mars' escape velocity of 5.1 Km/sec up to 5.9 Km/sec. It is found that for velocities greater than 5.4 Km/sec from 2 to 4% of the ejecta reach Earth within 10 m.y. This is about 1/3 of the Mars ejecta in this size range that will ever impact Earth.

From these considerations it is permissible to interpret SNC exposure ages as times of ejection from Mars. The principal dynamical problem remains one of cratering mechanics: acceleration of even small fragments to the required velocities.

(cont. on p. 466)

Meetings (cont. from p. 465)

P22B-05

Venus Gravity: Ishtar

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the dayside indicates that the O^+ ions in the topside ionosphere constitute an optically thick medium for resonance scattering of 834 Å airglow emission even at this high altitude. Simultaneous measurements of the O^+ density from the AE-E spacecraft at 460 km altitude near the equator are used to normalize the STP 78-1 airglow data. A g-value of $1.1 \times 10^{-8}\ s^{-1}$ is required for the ionization excitation of atomic oxygen leading to the production of O^+ atoms in ^4P state. The latitudinal distribution of O^+ density derived from the 834 Å airglow data shows a double peak (at ±13° lat) surrounding an equatorial trough, characteristic of the equatorial anomaly, at altitudes below 600 km and a single peak at the magnetic equator above 600 km. At high latitudes (> 20°), the O^+ densities in the summer hemisphere are substantially lower than those in the winter hemisphere.

SA21-07 REVISED ABSTRACT

Ion-Neutral Relative Velocities in the High Latitude F-Region

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L. E. WHARTON (all at: Goddard Space Flight Center, National Atmospheric and Space Administration, Greenbelt, MD 20771)

F-region neutral winds and ion drifts have been measured simultaneously for several high latitude perigee passes of the Dynamics Explorer (DE-2) spacecraft. The neutral wind vector is derived by appropriate merging of the meridional component measured remotely by the Fabry-Perot Interferometer (FPI) with the zonal component measured in situ by the Wind and Temperature Spectrometer (WATS). The ion drift vector is derived from in situ measurements by the Ion Drift Meter (IDM) and the Retarding Potential Analyser (RPA). These measurements enable the ion/neutral difference velocity to be determined at the satellite altitude along the orbital track. The F-region frictional heating of the ionic and neutral species is evaluated and discussed for the passes studied. In particular, ion temperatures inferred from the measured winds and drifts are compared with direct measurements made with the RPA. In addition, the effect of frictional heating on the compositional structure of the F-region is discussed using data from the Neutral Atmosphere Composition Spectrometer (NACS).

SA51-09A

Simultaneous Observations of Atmospheric Turbulence with 6 and 0.23 meter Wavelengths Radars

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B. J. Watkins, (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701

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SPR-Cosmic Rays

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SC22-10A

SOLAR CYCLE VARIATION OF THE LATITUDINAL GRADIENT OF SOLAR WIND SPEED AND 5 GeV COSMIC RAYS

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L. A. Fisk, and J. Lockwood, (Dept. of Physics, Univ. of New Hampshire, Durham, NH, 03824

Several recent researches have analyzed the properties of the solar wind as they are organized by the heliospheric current sheet. Synoptic K-coronometer observations allow one to ascertain the position of this current sheet during much of the solar cycle and to explore the properties of the solar wind and the cosmic ray population of the heliosphere with respect to a "heliomagnetic latitude" expressing distance from the current sheet. We have analyzed the latitudinal variation of solar wind speed and 5 GeV Cosmic Ray flux for the years 1964-82.

For all years during which a reliable gradient can be determined, the solar wind speed increases with distance from the current sheet. The gradient varies markedly throughout the solar cycle and attains a sharp maximum at solar minimum. A negative gradient of cosmic ray flux with increasing heliomagnetic latitude is well established during much of the solar cycle. There appears to be no clearly established, systematic variation of this gradient during the cycle.

These cosmic ray profiles will be compared with theoretical models based on the classical diffusion-convection and drift dominated theories of cosmic ray propagation.

* The National Center for Atmospheric Research is sponsored by the National Science Foundation.

Tectonophysics

T21A-09

STRESS AND STRAIN IN CENTRAL NEW HEBRIDES : EFFECTS OF THE SUBDUCTION-COLLISION PROCESS OF THE D'ENTRECASTEAUX ZONE

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DANIEL Jacques, ORSTOM Nouméa, New Caledonia
(Sponsor : MAILLET, P.)

A review of the structural evidences and the shallow seismicity, shows that radiant additional horizontal stresses generate a specific compressive stress regime in the Central New Hebrides. Produced deformations show a great resemblance with the theoritical strain field resulting from the indentation of a long narrow rigid plastic body i.e. the arc, by a flat rigid die, i.e. the d'Entrecasteaux zone. Thus, the central New Hebrides block, which is elastically bent under vertical stresses appears to be, further, plastically deformed and pushed eastward under horizontal stresses. Recent uplift of the eastern chain can be explained in this model. The strong plate interaction due to the subduction of the d'Entrecasteaux zone is supposed to be responsible for the compressive stress regime across the central part of the arc.

Examination of the different stress regimes throughout New Hebrides allows to segment the arc into 4 main units :

- the northern New Hebrides : a tensional zone from the north to the latitude 14°30
- the central New Hebrides ...

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T51-05A

Tapping of magmas from ubiquitous mantle heterogeneities

NORMAN H. SLEEP (Dept. of Geology and Geophysics, Stanford University, Stanford CA 94305)

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Volcanology, Geochemistry, and Petrology

V21A-15A

TITANIUM : HYDROMAGMAPHILE AND/OR NON HYDROMAGMAPHILE ELEMENT.

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Geophysical Year

New Listings

The complete Geophysical Year last appeared in the May 31, 1983, *Eos*.

A boldface meeting title indicates sponsorship or cosponsorship by AGU.

Aug. 8–13, 1983 Ninth International Association of Planetology International Symposium, Second IAP General Assembly, and Second International Planetological Conference, Brussels, Belgium. (Rene J. DeJaiffe, Royal Observatory of Belgium, Avenue Circulaire 3, B1180 Brussels, Belgium; telephone: 2–375–2484.)

Aug. 10–16, 1983 1983 Field Workshop on a Cross-Section of Archean Crust, Northeastern Ontario, Canada. (Pam Jones, Lunar and Planetary Institute, 3303 NASA, Road One, Houston, TX 77058; telephone: 713-486-2150.)

Aug. 11–16, 1983 Second International Symposium on River Sedimentation, Nanjing, China. Sponsors, UNESCO and United Nations Development Program. (Dou Guoren, Executive Secretary, The Second International Symposium on River Sedimentation, Nanjing Hydraulic Research Institute, 223 Guangzhou Road, Nanjing, 210024, People's Republic of China; telephone: 33662, cable 5710.)

Aug. 14–18, 1983 Conference on Glass in Planetary and Geological Phenomena, Alfred, N.Y. (L.D. Pye, New York State College of Ceramics, Alfred University, Alfred, NY 14802; telephone 607-871-2432.)

Aug. 15–27, 1983 Joint Meeting UNESCO/International Commission of Snow and Ice, Hamburg, Germany. (Sorin Dumitrescu, Director, Division of Water Sciences, UNESCO, 7, place de Fontenoy, 75700 Paris, France; telephone: 331-577-1610 x6093.)

Aug. 29-Sept. 7, 1983 International Symposium on Groundwater in Water Resources Planning and International Workshop on Groundwater in Rural Water Supply, Koblenz, Germany. Sponsors, International Hydrological Program and Operational Hydrology Programme. (K. Hofius, Secretary IHP/OHP, Postfach 309, D-5400 Koblenz, FRG.)

Sept. 1, 1983 International Workshop on the Application of Groundwater Protection and Rehabilitation Methods, Koblenz, Germany. Sponsor, International Hydrological Program. (Sorin Dumitrescu, Director, Division of Water Sciences, UNESCO, 7, place de Fontenoy, 75700 Paris, France; telephone: 331-577-1610 x6093.)

Sept. 3–4, 1983 Workshop on Past and Present Solar Radiation: The Record in Meteoritic and Lunar Regolith, Mainz, Germany. (Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058; telephone: 713-486-2150.)

Sept. 5–9, 1983 46th Annual Meteoritical Society Meeting, Mainz, Germany. (Friedrich Begemann, MPI für Chemie, Postfach 3060, D-6500 Mainz FRG.)

Sept. 11–14, 1983 Distribution System Symposium, Birmingham, Ala. Sponsor, American Water Works Association. (AWWA, 6666 West Quincy Ave., Denver, CO 80235; telephone: 303-794-7711.)

Sept. 12–16, 1983 International Water Supply Association Exhibition and Conferences, Brussels, Belgium. (IWSA Secretariat, 1 Queen Anne's Gate, London SW1 9BT, United Kingdom.)

Oct.-Nov. 1983 22nd Session of the UNESCO General Conference. (Sorin Dumitrescu, Director, Division of Water Sciences, UNESCO, 7, place de Fontenoy, 75700 Paris, France; telephone 331-577-1610 x6093.)

Oct. 9–12, 1983 Meeting: Association of Earth Science Editors, Houston, Tex. (Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058; telephone: 713-486-2150.)

Oct. 9–13, 1983 Nineteenth Annual AWRA Conference and Symposium, San Antonio, Tex. Sponsor, American Water Resources Association. (Kenneth D. Reid, Executive Director, AWRA, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814.)

Oct. 9–15, 1983 Sixth International Symposium on Environmental Biogeochemistry, Santa Fe, N.M. (James A. Brierley, Department of Biology, New Mexico Institute of Mining and Technology, Socorro, NM 87801.)

Oct. 17–20, 1983 American Astronomical Society Division of Planetary Sciences 15th Annual Meeting, Ithaca, N.Y. (Stephen J. Ostro, Space Sciences Building, Cornell University, Ithaca, NY 14853.)

Oct. 18–20, 1983 Fifth Conference on Hydrometeorology, Tulsa, Okla. (W.I. Pugsley, Program CoChairman, Chief Hydrometeorology Division, Canadian Climate Centre, 4905 Dufferin St., Downsview, Ont. M3H 5T4 Canada; telephone: 426 667-4617.)

Oct. 18–20, 1983 Tri-Services Infrared Backgrounds Symposium, Burlington, Mass. Sponsor, Department of Defense. (R.E. Murphy, AFGL/OPR, Hanscom AFB, MA 01731.)

Dec. 5–9, 1983 International Conference: Goundwater and Man, Sydney, Australia. (The Services Pty Ltd., P.O. Box 1929, Canberra City, ACT 2601, Australia; telephone: 062–49–8015; telex: AA62260 (UNIHS-ACTS).)

Dec. 5–9, 1983 Symposium on Optimization Techniques for Managing Groundwater and Stream-Aquifer Systems, San Francisco, Calif. Sponsor, AGU. (Steven G. Gorelick, U.S. Geological Survey, Mail Stop 21, 345 Middlefield Rd., Menlo Park, CA 94025; telephone: 415-323-8111 x2141 or Manoutch Heidari, Kansas Geological Survey, Lawrence, Kans.; telephone: 913-864-5672.)

Dec. 15–17, 1983 Second Annual Meeting of the Working Group on Mediterranean Ophiolites, Florence, Italy. (Giovanni B. Piccardo, Instituto di Mineralogia, Petrographia e Geochimica-Università, via La Pira 4, 50121 Firenze, Italy.)

March 19–23, 1984 Fifth Northern Research Basins Symposium and Workshop, Vierumaki, Finland. (Olli Fausaen, Secretary, Organizing Committee, Hydrological Office, Box 436, 00101 Helsinki 10, Finland.)

March 19–27, 1984 Sixth Session of the International Hydrological Program

April 1984 CSCE/ASCE Cold Regions Engineering Specialty Conference on Northern Resource Development, Edmonton, Alberta, Canada. (Daniel W. Smith, Dept. of Civil Engineering, University of Alberta, Edmonton, Alberta, T6G 2G7, Canada.)

April 1984 Arctic Water Pollution Research: Applications of Science and Technology, Yellowknife, N.W.T., Canada. (W.A. Bridgeo, Bridco Values, Ltd., P.O. Box 3161, Halifax South Post Office, Nova Scotia, B3J 3H5, Canada.)

April 3–5, 1984 Interdisciplinary Conference on Meeting the Water Needs of the Southwest, Dallas, Tex. (Michael A. Collins, School of Engineering and Applied Science, Southern Methodist University, Dallas, TX 75275; telephone: 214-692-3060.)

May-June 1984 12th International Congress on Irrigation and Drainage, Fort Collins, Colo. (ICID, 48 Nyaya Marg, Chanakyapuri, New Delhi 110012, India.)

June 11–13, 1984 Symposium on Critical Assessment of Forecasting in Western Water Resource Management, Seattle, Wash. Sponsor, American Water Resources Association. (Gary R. Minton, President, Resource Planning Associates, 113 Lynn Street, Seattle, WA 98109; telephone: 206-282-1681.)

June 24, 1984 International Symposium on Impermeable Barriers for Soil and Rock, Denver, Colo. (A. Ivan Johnson, Woodward-Clyde Consultants, 7600 E. Orchard Road, Englewood, CO 80111; telephone: 303-694-2770.)

June 24, 1984 International Conference on Geomembranes, Denver, Colo. (A. Ivan Johnson, Woodward-Clyde Consultants, 7600 E. Orchard Road, Englewood, CO 80111; telephone: 303-694-2770.)

June 25-July 7, 1984 Symposium on Space Observations for Climate Studies, Graz, Austria. Sponsor, World Climate Program. (S. Ruttenberg, Secretary, COSPAR Commission A, NCAR, Boulder, CO 80307.)

Chapman Conference on Natural Variations in Carbon Dioxide and the Carbon Cycle

Call for Papers

A Chapman Conference on "Natural Variations in Carbon Dioxide and the Carbon Cycle" will be held in Tarpon Springs, Fla., January 9–13, 1984. The purpose of the conference is to gather geologists who are studying various aspects of carbon cycle history together with geochemical modelers and with biologists, oceanographers, and meteorologists who are familiar with present and potential future relationships among the carbon cycle, atmospheric CO_2, and climate.

The potential climatic effects of anthropogenic CO_2 have stimulated a worldwide program of interdisciplinary carbon cycle research. At the same time, geologists have intensified their studies of such global processes as carbonate dissolution, organic carbon burial, sea level change, and other mechanisms that may have caused or reflected carbon cycle changes in the past. These largely independent trends in environmental and geological research are fundamentally related. The geological record shows a significant degree of carbon cycle variability before any human influence, suggesting the possibility of past atmospheric CO_2 fluctuations. What caused the carbon cycle variations? How were they related to atmospheric CO_2? Were they associated with climate changes consistent with the CO_2/climate predictive models? To what extent could natural variations contribute to the present CO_2 budget? What are the long-term geochemical implications of fossil fuel CO_2? These are among the questions that will be discussed at this conference.

The conference will consist of both invited and contributed papers. It is expected that about two-thirds of the participants will be geologists and about one-third will be from the CO_2 research community. One or two meeting sessions will be devoted to overview talks by experts on the application of ocean modeling, climate modeling, and biosphere modeling to CO_2 research. The remainder of the conference will emphasize the geological record. Because studies covering different time scales are often concerned with different kinds of processes and data, the meeting will be organized around six "time slices": (1) the last 2,000 years, (2) the last 20,000 years, (3) the last 2 million years, (4) the Cenozoic, (5) the Phanerozoic, and (6) the Precambrian. These categories are not meant to be rigidly restrictive; for example, the third category might include Pliocene hydraulic piston core data, and the fourth might include the Cretaceous/Tertiary boundary.

The 5-day conference will include morning and evening sessions, with afternoons devoted to informal discussions and recreation. In order to encourage interdisciplinary discussion, there will be no parallel sessions, and oral presentations will be allotted at least 30 minutes each. If necessary, space and time will be available for poster sessions. All of the oral presentations, and perhaps some of the poster presentations and summaries of discussions, will be published by AGU in a Geophysical Monograph within one year of the conference.

Arrangements are being made for grants to cover travel and conference costs for a number of attendees, including several students. Students wishing to apply should write to AGU by September 15, 1983, giving educational background, reasons for wanting to attend the conference, and current interests. Awardees will be selected by AGU in conjunction with the program committee. All who are interested in attending and in receiving later information on dates should write to Carbon Cycle Meeting, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (telephone toll free: 800-424-2488 or, in the D.C. area, 462-6903).

To submit an abstract, follow the abstract format published in *Eos*, June 28, 1983. There will be no abstract charge. All abstracts should be sent to E. T. Sundquist, U.S. Geological Survey, 431 National Center, Reston, VA 22092.

Abstract Deadline: September 15, 1983

Program Committee: E. T. Sundquist (co-convenor), U.S. Geological Survey; W. S. Broecker (co-convenor), Lamont-Doherty Geological Observatory; R. Bacastow, Scripps Institution of Oceanography; E. J. Barron, National Center for Atmospheric Research; W. H. Berger, Scripps Institution of Oceanography; T. C. Moore, Jr., Exxon Production Research Company; H. Oeschger, Physikalisches Institut, Universitat Bern; S. H. Schneider, National Center for Atmospheric Research.

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Aeronomy

...

Electromagnetics

0720 Electromagnetic theory

ULF/ELF ELECTROMAGNETIC FIELDS PRODUCED IN A CONDUCTING MEDIUM OF INFINITE EXTENT BY LINEAR CURRENT SOURCES OF INFINITE LENGTH

...

Geochemistry

...

Hydrology

...

Meteorology

3710 Boundary layer structures and processes
USE OF LONG-LIVED RADON DAUGHTERS AS INDICATORS OF EXCHANGE BETWEEN THE FREE TROPOSPHERE AND THE MARINE BOUNDARY LAYER

[illegible]

J. Geophys. Res., Green, Paper 3C1027

3715 Chemical composition and chemical interactions

[illegible]

J. Geophys. Res., Green, Paper 3C0815

3715 Chemical Composition and Chemical Interactions

[illegible]

J. Geophys. Res., Green, Paper 3C0865

3715 Chemical composition and chemical interactions
AN INVESTIGATION OF SULFATE PRODUCTION IN CLOUDS USING A FLOW-THROUGH CHEMICAL REACTOR MODEL APPROACH

[illegible] that atmospheric gases undergo in clouds. The model includes the simultaneous absorption of SO_2, NH_3, O_3, NO_x, HNO_3, CO_2 and H_2O_2, the accompanying dissociation and oxidation reactions in cloud water, considers solution electral-neutrality, and includes qualitative parameterization of cloud microphysics. The model is used to assess the importance of the oxidation reaction H_2O_2-S(IV), O_3-S(IV) and S(IV)-Mn^{++} catalysis, and the effects of cloud parameters such as drop size, rain intensity, liquid water content and updraft velocity. Both precipitating and non-precipitating clouds are studied.

Model results predict sulfate production rates varying from 3%/hr to 230%/hr (expressed in terms of gaseous SO_2 convesion rate). The actual rate is highly dependent on the chemical composition of the uptake air and the physical conditions of the cloud. Model results also show that both the H_2O_2 and the O_3 oxidation reactions can be significant.

J. Geophys. Res., Green, Paper 3C0777

3720 Climatology
SURFACE ALBEDO DATA FOR CLIMATIC MODELING
A. Henderson-Sellers (Department of Geography, University of Liverpool, P.O. Box 147, Liverpool, U.K.), M. F. Wilson

The climate system is driven, primarily, by energy absorbed at the surface. Surface albedo sensitivity is incorporated into all types of climate models and changes can lead to large feedback effects. For example, alterations in the extent and/or state of the cryosphere and large-scale modification of vegetation cause significant perturbations in climate model results. The specification of surface albedo in general circulation climate models (GCMs) differs. An improved and agreed surface albedo data set is urgently required for climate modeling. It is likely that the most appropriate means of achieving consistent and credible surface albedos is by using well-designed satellite surveillance to augment global inventories of soils and vegetation. However, retrieval of surface albedo values for all sky and surface conditions from satellite observations is difficult. Atmospheric distortion is especially hard to remove. Some of the sensitivity of GCMs to surface albedo values may be the result of inadequate parameterization of other climatic components. The accuracy of information demanded by climate modelers could be reduced and made more consistent. Recommendations are made for the implementation of a new global-scale observational programme with the aim of providing surface albedo data at an accuracy of ± 0.05 within 5-10 years. Immediate initiation is urged. (Climate models, satellite surveys, surface albedo).

Rev. Geophys. Space Phys., Paper 3R1085

3735 Electrical phenomena (Lightning)
POSITIVE CLOUD-TO-GROUND LIGHTNING RETURN STROKES
W.H. Beasley (Department of Electrical Engineering, University of Florida, Gainesville, FL 32611), M.A. Uman, D.M. Jordan and C. Ganesh

Several recent papers have reported positive cloud-to-ground lightning, but, in our opinion, none provides sufficiently direct evidence that positive return strokes occurred in any given case. Here we present observations that plainly demonstrate the occurrence of positive return strokes in a convective thunderstorm in Florida in August, 1982. These observations consist of waveforms of electric field correlated in time with light pulses received through a narrow collimated slit aimed about 1.2 degrees above a level plane and with videotape records of lightning channels. We studied lightning during one 15-minute interval at a range of 20 to 40 km. During this period we recorded time-correlated waveforms from three positive return strokes. The 10%-90% rise times of the electric fields, 1-5 μs, and of the light pulses, 3-6 μs, were similar to those of negative return strokes in the same storm. The light signals of the positive return strokes began 2 to 8 μs after the electric fields, consistent with return-stroke speeds of about 10^8 ms^{-1}, a value comparable to speeds of ordinary negative return strokes. (Lightning, Positive Return Strokes, Positive Ground Flashes)

J. Geophys. Res., Green, Paper 3C0813

3735 Electrical Phenomena (Thunderstorm Electrification)
TRANSIENT WORKMAN-REYNOLDS FREEZING POTENTIALS
J.H. Caranti and A.J. Illingworth (Dept. of Physics, UMIST, Manchester M60 1QD, UK)

Workman-Reynolds freezing potentials may result in thunderstorm electrification or aircraft precipitation static. Laboratory experiments on the development of these freezing potentials when bulk supercooled solution freeze, and when raindrops and cloud droplets freeze on impact with an ice surface, show that:

a) Any potentials developed are very much smaller than the published values for the quasi-static case.

b) In situations of atmospheric importance the drops will be supercooled, and such solutions are very much less efficient in developing potentials than non-super cooled ones.

c) Cloud droplets freeze very rapidly and if any freezing potential develops during this time then it decays in less than 5msecs and is statistically unlikely to affect charge transfer in subsequent collisions with ice crystals.

We conclude that in the atmosphere Workman-Reynolds potentials do not influence the charge transferred by colliding precipitation particles and briefly consider other relevant mechanisms. (Thunderstorm electrification, charging, precipitation static).

J. Geophys. Res., Green, Paper 3C0940

3740 General Circulation
LARGE-SCALE ATMOSPHERIC MIXING DERIVED FROM MERIDIONAL PROFILES OF Kr-85
W. Weiss, A. Sittkus, H. Stockburger, H. Sartorius (Max-Planck-Institut für Kernphysik, Außenstelle Freiburg-Schauinsland, Rosastr. 9, 7800 Freiburg i.Br., W. Germany), K.O. Münnich

Two north-south sections of the atmospheric concentration of Kr-85 are presented. The most striking feature of these sections is a large concentration jump at the respective geographical position of the Intertropical Convergence. Northern hemispheric residence times of 1 and 1.7 yrs resp. are estimated from the Kr-85 sections. The mean slope of the Kr-85 data observed between 10° and 40° N is in agreement with a meridional diffusivity of 1.6 · 10^{10} cm^2/sec. Fife years of a continuous Kr-85 record from two stations in 47.9° N, 7.8° E (difference in altitude : 1000 m) show a mean concentration increase per year of 0.5 pCi/m^3, an apparent seasonal variability (amplitude 1 - 2 pCi/m^3), and numerous peaks. The peaks originate from European sites. The yearly contribution of this (these) source(s) to the global Kr-85 discharge is at least 18%. The apparent seasonal variability of the Kr-85 concentrations is tentatively explained by the seasonal variability of the vertical mixing of the atmosphere.

J. Geophys. Res., Green, Paper 3C1112

3740 General Circulation
ROTATING FLUID EXPERIMENTS WITH AN ATMOSPHERIC GENERAL CIRCULATION MODEL
J. E. Geisler (Department of Meteorology, University of Utah, Salt Lake City, UT 84112), E. J. Pitcher and R. C. Malone

The traditional apparatus for rotating-fluid experiments in the laboratory is an annular container of fluid situated on a turntable. A fundamental difficulty in applying to atmospheric circulation problems the knowledge and understanding of the behavior of rotating fluids gained from these experiments is the geometrical difference between a rotating annulus and a rotating spherical shell. With a view toward identifying features of rotating fluid flow that are dependent on the geometry, we have undertaken rotating-annulus-type experiments with a numerical model in spherical coordinates. Rather than construct and test a model specifically for this purpose, we found it expedient to modify an existing general circulation model of the atmosphere by removing the model physics and replacing the lower boundary with a uniform surface. We present here a regime diagram derived from these model experiments, interpret its major features, and contrast these with the major features of rotating-annulus regime diagrams. A narrow region where one or two zonal wavenumbers are dominant is found within the wave regime. In contrast to the situation in the annulus, there is no upper symmetric regime in our results, and wave activity at low rotation rates appears to be maintained by barotropic rather than baroclinic processes. (Rotating-fluid experiments, geophysical fluid dynamics)

J. Geophys. Res., Green, Paper 3C1079

3740 General Circulation
LONG AND MEDIUM-SCALE WAVES IN THE LOWER STRATOSPHERE FROM SATELLITE-DERIVED MICROWAVE MEASUREMENTS
Wen-bi Yu, Russell L. Martin and John L. Stanford (Physics Department, Iowa State University, Ames, Iowa 50011)

Global grids have been constructed from high-quality TIROS-N Microwave Sounder Unit measurements which closely approximate the 30-150 mb geopotential thickness. The grids compare favorably with conventional analyses. Grids for January 1979 are spectrally analyzed by Fourier transform for zonal wavenumbers 1-10 over latitudes 80N to 80S. Both time-mean and transient medium-scale waves are discussed in some detail. In the time mean, wave 1 dominates all northern latitudes. In equatorial regions wave 1 also is dominant, but a secondary spectral peak is noted at wave 4. The most remarkable feature seen is a strong, medium-scale wave structure with eastward movement in Southern (summer) mid-latitudes. Zonal wavenumbers 5 and 6 have periods of about 10-15 days and 5 days, respectively. These results provide independent corroboration of such structures recently reported by several investigators. The mechanism by which the dominant medium-scale waves are maintained is not understood.

J. Geophys. Res., Green, Paper 3C0800

3755
STAR LINE-OF-SIGHT REFRACTION OBSERVATIONS FROM THE ORBITING ASTRONOMICAL OBSERVATORY "COPERNICUS", AND DEDUCTION OF STRATOSPHERIC STRUCTURE IN THE TROPICAL REGION.
R.L. White (C.S. Draper Laboratory, Cambridge, MA 02139), R.E. Tanner and R.S. Polidan.

Night-time observations from the Orbiting Astronomical Observatory COPERNICUS on May 14 and July 11, 1980, of visible light refraction by the limb of the atmosphere are presented. Irregularities of the measured refraction angle are interpreted to be the result of the thermal fine structure in the stratosphere. The observations are very sensitive to horizontally stratified structures with temperature variations of 2 to 5°K in narrow vertical bands, typical for the boundaries of wind ducts. This optical technique of remote sensing of atmospheric structure is particularly applicable to the altitude region of 20 to 40 km, where the vertical soundings by VHF and UHF tend to exhibit inadequate sensitivity.

J. Geophys. Res., Green, Paper 3C0594

3799 General Meteorology
A FREQUENCY DOMAIN ANALYSIS OF TRENDS IN DOBSON TOTAL OZONE RECORDS
P. Bloomfield (Dept. of Statistics, P.O. Box 37, Princeton University, Princeton, NJ 08544), G. Oehlert, M.L. Thompson, S. Zeger.

A frequency domain statistical model for the Dobson total column ozone data is introduced. This model extends variance-components analysis to the time series case and incorporates both temporal and spatial association found in the ozone data. We estimate the change in total ozone possibly associated with chlorofluorocarbons to be a 0.3% increase from 1970 through 1979, with a standard error of 0.65%. This estimate is most sensitive to long term phenomena in the data and is relatively insensitive to phenomena with time scales less than 2 years.

J. Geophys. Res., Green, Paper 3C1026

Mineralogy, Petrology, and Crystal Chemistry

4260 Paragenesis, petrography and petrogenesis
GRANITE PETROLOGY, ILLINOIS DEEP HOLE
Edward G. Lidiak (Geology and Planetary Science Department, University of Pittsburgh, Pittsburgh, PA 15260), Roger E. Denison

Two main basement granitoid types have been identified in core samples from the Illinois deep hole project. The main variety is a medium- to coarse-grained porphyritic biotite granite with phenocrysts of microcline perthite and less commonly quartz and sodic plagioclase in a matrix of these minerals and biotite, muscovite, fluorite, magnetite, ilmenite, zircon, hornblende, apatite, sphene, monazite, rutile, and clinopyroxene (relict). The texture is typically hypidiomorphic granular to recrystallized xenomorphic. The second main granitoid, which occurs in the upper part of hole UPH-3, is a fine-grained granoblastic to lepidoblastic gneissic granite that is distinct from and possibly older than the non-foliated granite. The textures of both rocks have been modified by a mild cataclastic shearing that has partially recrystallized the more susceptible mineral phases. Thin fracture planes that cross-cut the earlier foliations are common.

Microprobe analyses indicate that biotites in the gneissic granite are chemically distinct from those in the granite. Biotites in the gneissic granite have higher Fe/Fe + Mg ratio, FeO and Al_2O_3, and lower MgO and SiO_2. Reflection microscopy and microprobe analyses indicate that the oxide phases in the two rocks are also different. The oxides in the granite are magnetite and ilmenite, whereas hematite and pseudobrookite occur in the gneissic granite. The biotite and Fe-Ti oxide data represent additional evidence in support of the fact that the granite and gneissic granite are distinct rocks and probably not part of a continuous co-magmatic sequence.

Major element chemical analyses indicate that the granites have affinities to anorogenic rapakivi granites. The granites in the deep-holes are high in SiO_2, alkalis (Na_2O + K_2O), F, FeO/MgO; low in Al_2O_3, FeO, Fe_2O_3, TiO_2, MnO, and P_2O_5; and slightly low in MgO and CaO.

Magnetic susceptibility and density measurements correlate generally well with magnetic susceptibility and density logs. Magnetic susceptibilities range from 20-17,000 micro SI units, higher values correlate mainly with greater amounts of Fe-Ti oxides and biotite; lower values with gneissic rocks and muscovite content. Density measurements range from 2.595-2.685 Mg/m^3; denser rocks correlate positively with higher amounts of biotite and Fe-Ti oxides and inversely with microcline perthite content.

J. Geophys. Res., Red, Paper 3B0843

Oceanography

4705 Boundary layer and exchange processes
HEAT FLUXES OVER THE EASTERN TROPICAL PACIFIC AND ASPECTS OF THE 1972 EL NIÑO
R. K. Reed (Pacific Marine Environmental Laboratory, NOAA, Seattle, Washington 98105)

Recently evaluated flux formulas were used with an edited ship-of-opportunity data set for the 1970's decade to derive estimates of the individual surface heat fluxes and the total or net surface energy exchange for the eastern tropical Pacific. Absorbed solar radiation is the dominant heat flux in the region, and latent heat exchange is the second most important component; total cloud cover and wind speed are generally the most significant atmospheric variables. Over much of the area, the annual excess of net surface flux appears to be balanced by heat advection in the South Equatorial Current. Although the seasonal cycles of sea surface temperature seem to be produced by variations in net surface flux over parts of the area, they do not appear to balance off Peru and near the equator. Instead, water temperature seems to be noticeably affected by the seasonal cycle of upwelling and advection along the Peru coast.

This data set was also used to derive sea surface temperature and net surface heat flux departures from the mean for individual months during the 1972 El Niño. The magnitude and speed of the initial warming along the eastern ocean margin indicate changes in heat content at least an order of magnitude greater than any departures of net surface flux; this fact and the subsequent poleward and westward spreading of warm water support an advective origin, especially Wyrtki's hypothesis of an eastward propagating Kelvin wave. Subsequent changes during an El Niño episode also do not seem to be influenced appreciably by variations in surfarg heat exchange. (Heat fluxes, heat advection, El Nino).

J. Geophys. Res., Green, Paper 3C1139

4713 Circulation
EDDY ENERGY OF THE NORTHWEST ATLANTIC DETERMINED FROM GEOS-3 SATELLITE ALTIMETER DATA
B.C. Douglas (NOAA National Ocean Service, Rockville, MD 20852), R.E. Cheney and R.W. Agreen

From May 1975 to October 1978 the Geos 3 satellite altimeter made numerous repeated observations of sea surface topography in the North Atlantic, Caribbean, and Gulf of Mexico. By comparing members of about 1000 collinear pairs of altimeter profiles, we have determined mesoscale sea height variability and eddy kinetic energy in these ocean regions. Our results agree qualitatively with estimates made from traditional oceanographic surveys, but significant quantitative differences exist in certain areas, especially in the Gulf Stream between Florida and Cape Hatteras where the altimetric results show less variability. The reason for this appears to be due to differences in spatial sampling. Historical oceanographic measurements are relatively sparse and must be aggregated into small geographic boxes to compute variability statistics. Results therefore represent a combination of temporal and spatial variability. In contrast, repeated satellite altimeter tracks provide point measurements of changes of sea height and slope, enabling determination of temporal variability alone, a quantity more representative of eddy energy. It is important to make this distinction between space and time because in regions of strong horizontal gradient such as the Gulf Stream, spatial variability can exceed the temporal component. In mid-ocean where spatial variability is negligible, altimetric and oceanographic results are in excellent agreement. (Altimetry, Gulf Stream, satellite techniques, mesoscale variability).

J. Geophys. Res., Green, Paper 3C1111

4740 Marine geological processes
A STUDY OF THE OPTICAL CHARACTERISTICS OF THE SUSPENDED PARTICLES IN THE BENTHIC NEPHELOID LAYER OF THE SCOTIAN RISE
R. W. Spinrad (Bigelow Laboratory for Ocean Sciences, McKown Point, W. Boothbay Harbor, Maine, 04575), J. R. V. Zaneveld and J. C. Kitchen

Light transmission profiles have been used to study the optical properties of the suspended particles which are characteristic of the area of the Scotian Rise in the North Atlantic Ocean. This area is typified by very strong bottom currents and a highly variable bedform morphology. A good correlation (r = 0.96) has been found between the suspended volume and the light beam attenuation coefficient. This correlation is consistent with the fact that the cumulative slope of the hyperbolic particle size distribution is nearly constant throughout the region (slope = 3.1 ± 0.3). Numerical analysis of the optical data in conjunction with particle size analysis yields values of the index of refraction of the suspended particles of 1.20 ± 0.07 relative to water. The conclusion drawn from these results is that the Scotian Rise benthic zone is characterized by suspended particles of high relative index of refraction and size distributions which do not vary much with altitude above bottom or over periods of time of more than a year in spite of the extensive fluctuations in activity of the region. (Optical, particles, nepheloid layer, Scotian Rise)

J. Geophys. Res., Green, Paper 3C1020

4790 Instruments and Techniques
WIND MEASUREMENTS FROM AN ARRAY OF OCEANOGRAPHIC MOORINGS AND FROM F. S. METEOR DURING JASIN 1978
R. A. Weller (Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543), R. E. Payne, W. G. Large, and W. Zenk

During the Joint Air-Sea Interaction (JASIN) experiment conducted in the northern Rockall Trough in the summer of 1978 oceanographic moorings with surface buoys carrying wind recorders were deployed in an array designed to investigate the variability of the near-surface wind field at scales of from 2 to 200 km. The wind records together with observations taken on board the research vessels participating in JASIN have provided ground truth measurements for the sea surface wind velocity sensors on the SEASAT satellite. During most of the experiment the wind field was characterized by spatial scales large compared to the separations between the buoys. On several occasions spatial differences associated with cold fronts were identified and it was possible to track the passage of the front through the array. However, quantitative analysis of the variability of the wind field was complicated both by a lack of data due to mechanical failures of some instruments and by significant differences in the performance of the diverse types of wind recorders. Re-evaluation of the instruments used in JASIN and recent comparison of some of these [illegible]

J. Geophys. Res., Green, Paper 3C1089

Particles and Fields—Interplanetary Space

[illegible]

5399 General (Upstream ions)
UPSTREAM GYROPHASE BUNCHED IONS: A MECHANISM FOR CREATION AT THE BOW SHOCK AND THE GROWTH OF VELOCITY SPACE STRUCTURE THROUGH GYROPHASE MIXING
C. Gurgiolo, [illegible]

[illegible] The conditions necessary for the production of gyrophase bunched ions at the bow shock are [illegible]. The conditions are applied to the reflection [illegible] presented by Paschmann et al. (1980) showing that in their model, a portion of the incident parallel velocity is converted into reflected perpendicular velocity, the reflected particles are gyrophase [illegible]. The growth of velocity space structure in the gyrophase bunched distribution through gyrophase mixing is [illegible] explored. The structure is found to be similar to [illegible] reported in diffuse and dispersed ion events. This, together with the close correlation of the observation of gyrophase bunched ions with diffuse and dispersed ions has led us to speculate that these two populations may be closely related. (Upstream ions, gyrophase bunching, reflection mechanisms, bow shock).

J. Geophys. Res., Blue, Paper 3A1036

Particles and Fields—Ionosphere

5510 Auroral zone magnetic effects
TRIGGERING OF EXPANSIVE PHASE INTENSIFICATIONS OF MAGNETOSPHERIC SUBSTORMS BY NORTHWARD TURNINGS OF THE INTERPLANETARY MAGNETIC FIELD
Gordon Rostoker (Institute of Earth and Planetary Physics and Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1)

Over the past decade evidence has arisen suggesting that northward turnings of the interplanetary magnetic field after an interval of sustained southward IMF can trigger the onset of major substorm expansive phase effects. However, there has been some question in the past as to just how many substorms are triggered and whether, indeed, the correlation of substorm onsets with northward turnings was just a matter of chance. One reason for doubt was that the examples presented in the literature appeared during disturbed periods when the IMF was fluctuating significantly on a time scale of less than one hour and many substorm expansive phase intensifications were observable in the time frame where the correlation between the IMF and ground data was reported. The purpose of this paper is to present three clear-cut examples of isolated substorms where the reader may be able to convince himself of the validity of the reported triggering effect. For these events, it will be clear that the substorm current wedge triggered by the northward turning of the IMF carries substantially larger currents than the driven system associated with the overall substorm event. The role of the IMF in externally triggering episodes of Joule heating and particle precipitation within the substorm process will be discussed.

J. Geophys. Res., Blue, Paper 3A1023

5515 Auroras
A QUANTITATIVE DESCRIPTION OF THE SPATIAL DISTRIBUTION AND DYNAMICS OF THE ENERGY FLUX IN THE CONTINUOUS AURORA
J.A. Whalen (Air Force Geophysics Laboratory, Hanscom AFB, MA 01731).

Energy flux in the continuous (or diffuse) aurora is found to be constant instantaneously along contours which are defined analytically as a function of magnetic latitude and UT, coordinates which are approximated by circles in magnetic latitude-magnetic local time centered at a pole offset from the magnetic pole. As a consequence, the latitudinal distribution in these coordinates is the same instantaneously at all magnetic local times (the observed extent of which is 10 hr); changes also take place in the distribution do so simultaneously (within 15 minute UT resolution) throughout this extent.

These properties are observed in a case study of 8 hours duration by an array of ground-based digital ionospheric sounders which span the 10 hours of magnetic local time at auroral latitudes. Energy flux of the continuous aurora is derived from the relationship between auroral E-layer critical frequency which is measured simultaneously at 15 minute intervals by all members of the array.

Two latitudinal distributions are identified: the principal one is a Gaussian distribution at lower latitude; a separate distribution which is of lower intensity occurs at higher latitude; the two correspond respectively to the central plasma sheet and boundary plasma sheet regions of particle precipitation. The central plasma sheet distribution is found in all 32 determinations to be well described by a single Gaussian function of full-width-at-half-maximum. Accordingly the distribution of the entire latitude-local time distribution history is described quantitatively by the time history of three parameters, the Gaussian maximum energy flux [illegible] varies between extremes of 0.25 and 7 [illegible], the latitude of the maximum (which varies throughout a range of 5°). The determination of these parameters every 15 minutes resolves such rapidly varying features as substorm onset; the 8 hour duration incorporates long term features as substorm lifetime and [illegible] latitude variation. A number of areas of agreement are found between results reported here and those reported by others. In particular, evidence that the continuous aurora is highly uniform exists not only in this case study but also in statistical studies which [illegible] energy flux contours to be offset circles [illegible] particle precipitation, ionospheric sounding)

J. Geophys. Res., Blue, Paper 3A0980

[illegible]

Particles and Fields—Magnetosphere

[illegible]

30th Pacific Northwest Regional Meeting

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Call previously published in EOS May 17.

[illegible]

5753 Magnetic Storms
LONGITUDINAL STRUCTURE OF SUBSTORM INJECTIONS AT SYNCHRONOUS ORBIT
R. L. Arnoldy (Space Science Center, University of New Hampshire, 03824), T. E. Moore
[illegible]
J. Geophys. Res., Blue, Paper 3A0892

5736 Magnetic tail
DEVELOPMENT OF SUBSTORM ACTIVITY IN MULTIPLE-ONSET SUBSTORMS AT SYNCHRONOUS ORBIT
T. Nagai (Space Science Laboratory, NASA/Marshall Space Flight Center, Huntsville, AL 35812), D. N. Baker and P. R. Higbie
[illegible]

5736 Magnetic Tail (Energetic Particles)
ENERGETIC PARTICLES IN THE VICINITY OF A POSSIBLE NEUTRAL LINE IN THE PLASMA SHEET
E. Möbius (Max-Planck-Institut für Physik und Astrophysik, Institut für extraterrestrische Physik, 8046 Garching, F.R.G.), M. Scholer, D. Hovestadt, G. Paschmann, and G. Gloeckler
[illegible]
J. Geophys. Res., Blue, Paper 3A0731

5739 Magnetopause
INTERACTION OF RING CURRENT IONS WITH THE MAGNETOPAUSE
M. Scholer (Max-Planck-Institut für Physik und Astrophysik, Institut für extraterrestrische Physik, 8046 Garching, FRG) and F. M. Ipavich
[illegible]

[illegible]
J. Geophys. Res., Blue, Paper 3A0920

5739 Magnetopause
LOW ENERGY PARTICLES AT THE BOW SHOCK, MAGNETOPAUSE, AND OUTER MAGNETOSPHERE OF SATURN
R. G. Maclennan and L. J. Lanzerotti (Bell Laboratories, Murray Hill, N.J. 07974), S. M. Krimigis and P. J. Lepping
[illegible]
J. Geophys. Res., Blue, Paper 3A0797

5745 Magnetosphere configuration
STRUCTURE AND DYNAMICS OF SATURN'S OUTER MAGNETOSPHERE AND BOUNDARY REGIONS
[illegible]
J. Geophys. Res., Blue, Paper 3A0947

5755 (Plasma Instabilities)
SIMULATION OF THE ION TEARING INSTABILITY IN THE PRESENCE OF A BACKGROUND PLASMA
[illegible]
J. Geophys. Res., Blue, Paper 3A0948

5753 Particles and Fields (Plasma Instabilities)
SIMULATIONS OF BEAM EXCITED MINOR SPECIES GYROHARMONICS IN THE PORCUPINE EXPERIMENT
[illegible]
J. Geophys. Res., Blue, Paper 3A1024

5760 Plasma motion, convection, or circulation
LOW-ENERGY (< 100 eV) ION PITCH ANGLE DISTRIBUTIONS IN THE MAGNETOSPHERE BY ISEE 1
T. Nagai (Space Science Laboratory, NASA/Marshall Space Flight Center, Huntsville, AL 35812), J.F.E. Johnson, and C. R. Chappell
[illegible]
J. Geophys. Res., Blue, Paper 3A0797

5770 Short-period (less than 1 day) variations of magnetic field
THE LOCALIZATION OF Pi2 PULSATIONS: GROUND-SATELLITE OBSERVATIONS
[illegible]
J. Geophys. Res., Blue, Paper 3A1061

5770 (Short-period variations of magnetic field)
POLARIZATION PATTERNS OF Pi 2 MAGNETIC PULSATIONS AND THE SUBSTORM CURRENT WEDGE
[illegible]
J. Geophys. Res., Blue, Paper 3A1107

5785 Whistlers
A THEORETICAL STUDY OF PLASMASPHERIC HISS GENERATION
[illegible]

5795 Miscellaneous (Upstream Particles)
OBSERVATIONAL EVIDENCE ON THE ORIGIN OF IONS UPSTREAM OF THE EARTH'S BOW SHOCK
M. F. Thomsen (MS D438, Los Alamos National Laboratory, Los Alamos, NM 87545), S. J. Schwartz and J. T. Gosling
[illegible]

are compared with observations of upstream field-aligned beams and "gyrating ion" events. A kinematic formalism in a frame of reference in which the motional electric field vanishes is used. Specular reflection of a fraction of the incident solar wind is found to be the most likely explanation of gyrating ion events observed upstream of shocks ranging from quasi-parallel to nearly perpendicular. The recent hypothesis that field-aligned beams are the result of leakage from the magnetosheath of ions which were originally specularly reflected at quasi-perpendicular portions of the shock provides good agreement with observed energies of many field-aligned beams. Of the several source hypotheses examined, only magnetic moment conserving reflection of solar wind ions is capable of accounting for two very energetic beam events. Moreover, during a single encounter with the shock, it is possible that the magnetic moment of an ion should not be conserved, that multiple encounters of ions which are originally specularly reflected at the shock can produce an upstream distribution of particles which appear to have conserved their magnetic moment. (bow shock, upstream particles)
J. Geophys. Res., Blue, Paper 3A1103

5799 (Jupiter's Aurora)
DETECTION OF X-RAYS FROM JUPITER
A. E. Metzger (Earth and Space Sciences Division, Jet Propulsion Laboratory, Pasadena, CA 91109), D. A. Gilman, J. L. Luthey, K. C. Hurley, H. W. Schnopper, F. D. Seward, and J. D. Sullivan
Soft X-rays have been detected coming from Jupiter using the imaging proportional counter and high resolution imaging detectors on the Einstein X-ray astronomy satellite. The measured flux density of $\sim 6 \times 10^{-4} cm^{-2} s^{-1}$ at Earth corresponds to an X-ray luminosity of $\sim 4 \times 10^{9}$ watts in the 0.2–3.0 keV energy band. Detector energy resolution is insufficient to distinguish a line spectrum from a continuum. However, the shape of the response and the observed X-ray power indicate that the source of this auroral emission is not electron bremsstrahlung as on the Earth, but is most probably line emission from O and S ions with energies between 0.01 and 5 MeV/nuc precipitating from the ramp of the Io plasma torus around L ≈ 8. (X-ray, line emission)
J. Geophys. Res., Blue, Paper 3A1049

5799 General (Low-Energy Plasma)
CHARACTERISTICS OF LOW-ENERGY PLASMA IN THE PLASMASPHERE AND PLASMA TROUGH
D. L. Reasoner, P. D. Craven (Marshall Space Flight Center, ES53, Huntsville, AL 35812), C. R. Chappell
Data from the Light Ion Mass Spectrometer (LIMS) on the SCATHA satellite is used to study the low-energy (< 100 eV) plasma populations at a near-geosynchronous orbit. The characteristics of the plasma in the noon-to-midnight quadrant during quiet to moderately active times are emphasized. The observed plasma populations tended to group into three distinct types. These were a warm trapped distribution, a warm field aligned distribution, and a distribution with $T_i \leq 1$ eV. The cold plasma was seen after 1800 LT during periods of magnetic quiet and was observed to be flowing sunward during active periods. The cold plasma is identified as encounters with the plasmasphere, while the warm plasma populations are assumed to lie outside of the plasmasphere in the plasma trough. The presence of these warm plasma populations may be responsible for the differences in the shape of the bulge-region plasmasphere derived from whistler measurements [Carpenter, 1966] and from in-situ measurements made on OGO 5 [Chappell et al., 1970]. The effects of the spacecraft potential upon the low-energy plasma measurements is studied. A threshold effect may be operative whereby when the cold plasma density decreases to less than about 3 ions/cm³, the spacecraft potential rises to a positive value such that cold plasma fluxes are effectively excluded from detection. (SCATHA, particle measurements, plasmasphere).
J. Geophys. Res., Blue, Paper 3A1052

Physical Properties of Rocks

5110 Elasticity, fracture and flow
OPENING OF A FAULT AND RESULTING SLIP DUE TO INJECTION OF FLUID FOR THE EXTRACTION OF GEOTHERMAL HEAT, 2
K. Hayashi (Department of Mechanical Engineering, Tohoku University, Sendai 980, Japan), H. Abé
Further details of the behavior of a fault with a fluid-filled region are presented, where an oblique fault is modeled by an interface across which two elastic bodies are in frictional contact and the tectonic stresses varying linearly with respect to depth are taken into account. It is shown that a fault can keep fluid if there exists a spatially fluctuating tectonic stress field superimposed on the linear depth-dependent stress field although the fluctuation magnitude must be larger than a lower limit when the fault is oblique. It is also revealed that, except for the case of a horizontal fault, there is an upper limit for the size of the fluid-filled region even if the fluctuating stress field is spatially periodic. As the fluid-filled region is created, slip spreads simultaneously along the fault. This resulting slip is also analyzed. (fault, geothermal heat, hot dry rock)
J. Geophys. Res., Red, Paper 3B0700

6110 Elasticity, fracture, and flow
SHOCK COMPRESSION OF SINGLE-CRYSTAL FORSTERITE
J. Peter Watt (Department of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181) and Thomas J. Ahrens
Dynamic compression results are reported for single crystal forsterite shocked along the orthorhombic a and c axes to pressures between 130 and 165 GPa. Results for both directions are well described by a single curve, but are displaced to densities 0.20 g/cm³ lower than previous results for b axis crystal forsterite shocked along the b axis to pressures in excess of 100 GPa. Earlier data of Syono et al. exhibit marginal evidence for similar behavior in the mixed-phase region from 60 to 90 GPa. b axis shock-loaded forsterite is most compressible above 50 GPa. The present results represent the lowest pressures at which shock properties have been observed to depend on crystal orientation. Theoretical Hugoniots for both mixed-oxide and perovskite-structure high pressure assemblages of forsterite constructed with recent experimental data are essentially identical and are in agreement with the b-axis experimental data. The a and c axis data are also consistent with a high pressure assemblage because the uncertainties in the equation of state parameters lead to a broad range of calculated Hugoniots. A calculated "average" Hugoniot is less dense than the preferred theoretical Hugoniots by about 0.13 g/cm³, in agreement with previous measurements on dense polycrystalline forsterite. Interpolation between the single-crystal Hugoniots and Hugoniots for fayalite and Twin Sisters dunite data not previously well described by hydrodynamics. The steep release paths are very similar for the a and c axes, while the release paths for the b axis are shallower. Hugoniot elastic limits measured along the a and b axes are in good agreement with previous determinations by Syono et al., but the crystal along the a axis demonstrate a triple-wave structure: two deformational shock waves as well as the second shock, a feature not previously observed, and a third shock, with an amplitude of about 9 GPa and a temperature of about 350°K, could perhaps be explained in terms of the forsterite α + β or γ phase transformation. (shock waves, equations of state, lower mantle)
J. Geophys. Res., Red, Paper 3B1078

6160 Phase changes
THERMAL CONDUCTIVITY OF MINERALS AT HIGH PRESSURE THE EFFECT OF PHASE TRANSITIONS
Roufosse, M.C. (Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, 02138), R. Jeanloz
Theory predicts and measurements confirm that anharmonic effects such as the lattice thermal resistivity, the Grüneisen parameter, the coefficient of thermal expansion generally decrease in relation to increasing density upon compression of solids. The Debye temperature continuum model further predicts a discontinuous decrease in anharmonic properties during a phase transition with a density increase, in contradiction with available experimental data on alkali halides. The present results, calculated from a model based on interatomic potentials. This model correctly predicts an increase in anharmonic properties for simple compounds transforming from a β- to an α-structure. These results stress the importance of interatomic distances as well as density in determining changes in thermodynamic properties during polymorphism. The change in crystal structure across a phase transition also affects the thermal conductivity via Brillouin-zone boundaries over the interacting phonon modes. We have, used in the calculation, either the bulk sound speed, or the Debye average velocity obtained from the longitudinal and transverse velocities (in both cases, theoretically derived from the interatomic potentials). We have found that the pressure dependence of thermal conductivity determined from the bulk sound speed agrees much better with experimental data for both phases than that determined from the average velocity. Apparently, optical modes contribute less to the change of thermal conductivity with compression than had been thought.
J. Geophys. Res., Red, Paper 3B0923

Planetology

6510 Atmospheres of planets
DISTRIBUTION OF MOLECULAR HYDROGEN IN THE ATMOSPHERE OF TITAN
J.-L. Bertaux and G. Kockarts (Institut d'Aéronomie Spatiale, 3 Avenue Circulaire, B-1180 Bruxelles, Belgium)
The diffusion problem of light gases in the atmosphere of Titan is reassessed after Voyager encounter. The pre-Voyager theoretical work of Hunten (1973a) is completed by the use of parameters derived from Voyager encounter: the radial distances of turbopause level (3500 km) and critical level (4100 km), the exospheric temperature (186 K) and the volume mixing ratio of 0.002 for H_2. An analytical expression of the solution of the diffusion equation is given for a spherical geometry and an isothermal atmosphere. It is used to predict an altitude profile of H_2 in the upper atmosphere of Titan. The modification of this profile by a possible return flow of H_2 from a torus to the atmosphere of Titan is adressed, and is found negligible since there is observational evidence from Voyager that the H_2 density is less than 100 cm^{-3} in the torus, at large distance from Titan. The H_2 concentration at the exobase level is $3.1 \times 10^{7} cm^{-3}$, and the thermal escape of H_2 is nearly equal to the diffusion limiting flux of 3.4×10^{9} molecules $cm^{-2} s^{-1}$ at the turbopause level. Photodissociation of CH_4 has to provide for an equal constant supply of H_2. (Titan, atmosphere, composition)
J. Geophys. Res., Blue, Paper 3A1034

6510 ATMOSPHERES OF PLANETS
SATURN'S UPPER ATMOSPHERE FROM THE VOYAGER 2 EUV SOLAR AND STELLAR OCCULTATIONS
G.R. Smith (Center for Space Sci., Univ. of Southern Calif., Tucson, Arizona, 85713), D.E. Shemansky, J.B. Holberg, A.L. Broadfoot, B.R. Sandel, J.C. McConnell
The temperature and composition of the upper atmosphere of Saturn have been inferred from Voyager 2 ultraviolet spectrometer occultation measurements made by observing the sun and the star δ-Scorpii while they were being occulted by Saturn. The observations analyzed here provide atmospheric parameters from 2900 km down to 960 km above the 1-bar level referred to the equator. The temperature in the model simulation of the data is 420 ± 30 K down to about 1600 km. Below 1600 km the temperature decreases with a variable lapse rate down to 120 ± 30 K near the methane homopause located at 1010 ± 40 km. A constant temperature at 120 K is applied in the model for the region of the methane homopause down to 960 km where the present analysis terminates. Column amounts of H_2 and H were measured from 2900 km down to about 1300 km, giving densities of $[H_2] \sim 1.0 \times 10^{8}$ cm^{-3} and $[H] \sim 5.5 \times 10^{7}$ cm^{-3} near the exobase at 2500 km. Near the methane homopause the H_2 density is $[H_2] = 1.2 \times 10^{11}$ cm^{-3} with a CH_4 number density mixing ratio of 6.0×10^{-4}. The eddy diffusion coefficient in the vicinity of the methane homopause is estimated to be $\sim 5.0 \times 10^{4}$ cm^{2} s^{-1}. The atomic hydrogen density profile suggests a downward H flux of $\sim 1.5 \times 10^{9}$ cm^{-2} s^{-1} from near the exobase down to a terminal boundary of about 1200 km.
J. Geophys. Res., Blue, Paper 3A0905

6510 Atmospheres of Planets
VOYAGER 2 OBSERVATIONS OF SATURN'S MID-LATITUDE CLOUD FEATURES: MORPHOLOGY, MOTIONS, AND EVOLUTION
L.A. Sromovsky (Space Science and Engineering Center, University of Wisconsin-Madison, Madison, Wisconsin, 53706), H.E. Revercomb, R.J. Krauss, and V.E. Suomi
Both Saturn's large-scale cloud bands and the distribution of its local cloud features have a characteristic zonal organization. The latitudes between 30°N and 45°N contain two oppositely directed jets in close proximity, with many bright, active features in the westward jet, and an unusual ribbon-like wave feature encircling the planet in the eastward jet. Several of the smaller features within the westward jet do not remain at fixed latitudes, and interact with each other. One group of v-shaped features is found to have periods of high activity correlated with the passage of a cyclonic bright spot. The ribbon wave was Fourier analyzed to determine its spectral composition. The greatest power is near wavenumber nine, with significant additional peaks appearing at planetary wavenumber 19, 25-27, 35-38, and 47-51. The phase velocity increases with wavenumber, but is not well-described by a Rossby-Haurwitz dispersion relation. The curvature of the mean wind profile obtained from cloud tracking indicates that the westward jet exceeds the standard barotropic instability condition, while the eastward jet marginally exceeds the deep-circulation instability condition of Ingersoll and Pollard (Icarus, 52, 1982). The rms eddy velocities on Saturn are less than half as large as those observed on Jupiter. (Saturn, cloud morphology, atmospheric circulation.)
J. Geophys. Res., Blue, Paper 3A1038

6510 Atmospheres of Planets
THE REACTION $NH_2 + PH_3 \rightarrow NH_3 + PH_2$: ABSOLUTE RATE CONSTANT MEASUREMENT AND IMPLICATION FOR NH_3 AND PH_3 PHOTOCHEMISTRY IN THE ATMOSPHERE OF JUPITER
S. S. Bosco, W. D. Brobst, D. F. Nava and L. J. Stief (Goddard Space Flight Center, Astrochemistry Branch, Greenbelt, Maryland 20771)
It has been suggested that the photochemistries of NH_3 and PH_3 are linked in the upper atmosphere of Jupiter. Specifically, the reaction $NH_2 + PH_3 \rightarrow NH_3 + PH_2$ would, if the rate were fast enough at Jovian stratospheric temperatures, regenerate ammonia in the same time accelerating the decomposition of phosphine. The absolute rate constant for this reaction has been measured over the temperature interval 218–456 K using the technique of flash photolysis-laser induced fluorescence (FP-LIF). NH_2 radicals were produced by flash photolysis of ammonia highly diluted in argon and the decay of fluorescent NH_2 photons was measured by multiscaling techniques. At each of the five temperatures employed in the study, the results were shown to be independent of variations in $[PH_3]$, total pressure (argon) and flash intensity (i.e., initial $[NH_2]$). The rate constant results are best represented for $218 \le T \le 456$ K by the expression $k = (1.52 \pm 0.16) \times 10^{-12} \exp(-928 \pm 56/T)$ cm^{3} $molecule^{-1}$ s^{-1}, where the error quoted is one standard deviation. This represents the first determination of the rate constant for the reaction $NH_2 + PH_3$. The data are compared with an estimate made in order to account for results of the radiolysis of NH_3-PH_3 mixtures. The Arrhenius parameters determined here for $NH_2 + PH_3$ are contrasted with those for the corresponding reactions of H and OH with PH_3. The results are also discussed theoretically and the implications considered for models of the photochemistry of the atmosphere of Jupiter. Since we now find that the rate constant for the reaction $NH_2 + PH_3 \rightarrow NH_3 + PH_2$ is two orders of magnitude slower than required in the model, it appears that this reaction can make only a negligible contribution to both the recycling of NH_3 and the decomposition of PH_3 in the upper atmosphere of Jupiter. (ammonia photochemistry, Jupiter, phosphine.)
J. Geophys. Res., Green, Paper 3C1140

6510 ATMOSPHERES OF PLANETS
SATURN'S UPPER ATMOSPHERE FROM THE VOYAGER 2 EUV SOLAR AND STELLAR OCCULTATIONS
G.R. Smith (Center for Space Sci., Univ. of Southern Calif., Tucson, Arizona, 85713), D.E. Shemansky, J.B. Holberg, A.L. Broadfoot, B.R. Sandel, J.C. McConnell
The temperature and composition of the upper atmosphere of Saturn have been inferred from Voyager 2 ultraviolet spectrometer occultation measurements made by observing the sun and the star δ-Scorpii while they were being occulted by Saturn. The observations analyzed here provide atmospheric parameters from 2900 km down to 960 km above the 1-bar level referred to the equator. The temperature in the model simulation of the data is 420 ± 30 K down to about 1600 km. Below 1600 km the temperature decreases with a variable lapse rate down to 120 ± 30 K near the methane homopause located at 1010 ± 40 km. A constant temperature at 120 K is applied in the model for the region of the methane homopause down to 960 km where the present analysis terminates. Column amounts of H_2 and H were measured from 2900 km down to about 1300 km, giving densities of $[H_2] \sim 1.0 \times 10^{8}$ cm^{-3} and $[H] \sim 5.5 \times 10^{7}$ cm^{-3} near the exobase at 2500 km. Near the methane homopause the H_2 density is $[H_2] = 1.2 \times 10^{11}$ cm^{-3} with a CH_4 number density mixing ratio of 6.0×10^{-4}. The eddy diffusion coefficient in the vicinity of the methane homopause is estimated to be $\sim 5.0 \times 10^{4}$ cm^{2} s^{-1}. The atomic hydrogen density profile suggests a downward H flux of $\sim 1.5 \times 10^{9}$ cm^{-2} s^{-1} from near the exobase down to a terminal boundary at about 1200 km.
J. Geophys. Res., Blue, Paper 3A0905

6545 Interior of planets
HOT SPOT HEAT TRANSFER: ITS APPLICATION TO VENUS AND IMPLICATIONS TO VENUS AND EARTH
Paul Morgan (Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058, USA) and Roger J. Phillips
Gross similarities between Earth and Venus suggest that both planets might be expected to lose heat by the same mechanism. Available data do not resolve plate tectonics on Venus, however, and other heat loss mechanisms, such as hot spot heat loss, have been suggested. Using a model which gives a relationship among surface elevation, lithospheric thickness and heat flux, we test the hot spot heat loss mechanism for Venus and determine that it can easily explain the predicted heat loss of the planet with a modest number of hot spots (on the order of 35). Approximately 93% of the mapped topography of Venus can be explained solely on the basis of lithospheric thickness variations. Additional compensation is required for topography above a radius of 6053 km, and this can be effected by incorporating a variable thickness crust into the model. If crust is assumed to be generated on the crests of the hot spots, probably by processes associated with volcanism, the model is consistent with almost 99% of the mapped Venus topography. The model is also basically consistent with available gravity data and interpretations which indicate compensated topography and great depths of compensation (100–1000 km) for the mid-latitudes of the planet. The remaining approximately 1% of the topography, not explained by hot spot crustal generation, is thought to be compensated at a shallower depth primarily by variations in crustal thickness, not directly related to hot spot volcanism. The models, relating surface elevation to lithospheric thickness and heat flow, are grossly consistent with either a plate tectonic or hot spot heat loss mechanism for Venus. The range of lithospheric thicknesses implied by the range of elevations on Venus implies that if plate tectonics is the dominant heat loss mechanism on Venus, the mean plate velocities are slower than on Earth. Slow spreading ridges should be resolvable by the available Venus topographic data, but are not apparent. A comparison and analysis of the hypsometric curves for the Earth and Venus suggests basic differences between the curves, the skewed terrestrial ocean floor curve being consistent with plate tectonics, but the relatively symmetrical venusian curve indicates that either plate tectonics differs on Venus from the terrestrial analogue, or plate tectonics does not dominate the topographic expression of Venus tectonism. The venusian curve is consistent with a hot spot heat loss mechanism. A hot spot crustal genesis mechanism is proposed which would probably result in crust very similar to the granite-greenstone terrains of many terrestrial Archaean cratons. We speculate that hot spot heat loss may have preceded plate tectonics as the dominant terrestrial heat loss mechanism. (Venus, heat loss, thermal isostasy, hot spot tectonics)
J. Geophys. Res., Red, Paper 3B0748

6575 Surface of Planets
SPECTRAL PROPERTIES OF MIXTURES OF MONTMORILLONITE AND DARK CARBON GRAINS: IMPLICATIONS FOR REMOTE SENSING MINERALS CONTAINING CHEMICALLY AND PHYSICALLY ADSORBED WATER
R. N. Clark (Planetary Geosciences Division, Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii, 96822)
The spectral properties from 0.4 to 3μm of montmorillonite plus dark carbon grains (called opaques) of various sizes are studied as a function of the weight fraction of opaque material present. The reflectance level and band depths of the 1.4-, 1.9-, 2.2-, and 2.8-μm water and/or OH absorption features are analyzed using derived empirical relationships and scattering theory. It is found that the absorption band depths and reflectance level are a very nonlinear function of the weight fraction of opaques present but can be predicted in many cases by simple scattering theory. The 2.8-μm bound water fundamental band is the most difficult absorption feature to suppress. The overtone absorptions are suppressed a greater amount than the fundamental but are still apparent even when 10–20 wt% opaques are present. Thus the band depth ratio of one overtone by the fundamental or to another lower overtone varies as a function of the weight fraction of opaques present. The relationships observed, and the simple scattering theory presented show that quantitative compositional remote sensing studies are feasible for surfaces containing complex mineral mixtures of this sort. The question of the uniqueness of quantitative remote sensing is discussed.
J. Geophys. Res., Red, Paper 3B1065

6575 Surface of Planets
SATURN'S SMALL SATELLITES: VOYAGER IMAGING RESULTS
P. Thomas and J. Veverka (Laboratory for Planetary Studies, Cornell University, Ithaca, N.Y. 14853), D. Morrison, M. Davies, and T. V. Johnson
Voyagers 1 and 2 provided images of sufficient resolution for morphologic and photometric studies of Saturn's small satellites. These objects, all very difficult to observe from Earth, orbit Saturn at distances of 2.3 to 6.3 R_S (just outside the A-ring to the orbit of Dione) and range in mean diameter from 22 to 188 km. All are irregularly shaped (long/short axis ratios range from 1.4 to 2.0) and probably heavily cratered. While impacts have apparently been important in shaping these objects, observed crater densities suggest that the present forms may have survived for about 4 billion years. Geometric albedos vary from 0.4 to at least 0.8. These albedos and the few color data available are similar to those of larger Saturn satellites which are known to have surfaces made predominantly of water ice. The range of observed albedos could be explained by minor variations in the amount of dark, opaque contaminants. (satellites, surfaces, Saturn)
J. Geophys. Res., Red, Paper 3B0389

6599 General or Miscellaneous
IMPLICATIONS OF VOYAGER DATA FOR ENERGETIC ION EROSION OF THE ICY SATELLITES
L. J. Lanzerotti, C. G. Maclennan, W. L. Brown (Bell Laboratories, Murray Hill, N.J. 07974), R. E. Johnson, L. A. Barton, C. T. Reimann, J. W. Garrett, and J. W. Boring (Department of Nuclear Engineering and Engineering Physics, University of Virginia, Charlottesville, Virginia 22901)
The possible production of a neutral particle "torus" by magnetospheric particle sputtering of the icy satellites (Enceladus, Tethys, Dione, Rhea) of Saturn is discussed. Particle spectra from the Voyager Low Energy Charged Particle experiment are used together with laboratory-derived erosion rates and velocity distributions for the ejected species. An extended torus region in the inner magnetosphere of Saturn is expected, with H_2O escape fluxes in the vicinities of the satellites varying from ~2 to 7×10^{7} mol/cm²/sec for incident protons and from ~6 to 14×10^{8} mol/cm²/sec if the incident ions are all oxygen. (ice sputtering, Saturn, magnetosphere particles).
J. Geophys. Res., Blue, Paper 3A0903

6599 General
MAGNETIC DRIFTS AT IO: DEPLETION OF 10 MEV ELECTRONS AT VOYAGER 1 ENCOUNTER DUE TO A FORBIDDEN ZONE
R. E. Goldstein (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, 91109), and W.-H. Ip
The possibility that the partial drop-out of the 10 MeV electrons observed at Voyager 1 encounter with Io might be explained by a forbidden zone is investigated. Because the convection velocity in the vicinity of Io decreases, grad B drifts of energetic electrons opposing the convection result in a forbidden region around Io. It is found that the location and magnitude of the 10 MeV electron depletion calculated on this basis agrees well with the location found by mapping along draped field lines from the Voyager trajectory to the location of Io. The depletion of 10 MeV electrons thus should not be construed as evidence for a local dipole magnetic field at Io. If the forbidden zone explanation for the 10 MeV drop out observed by Voyager is correct, then no electrons in this energy range would be lost to the surface of Io and there should not be a wake extending behind Io in which electrons of energies ≥ 10 MeV are depleted. Such a depletion of electrons near 9 MeV was observed by Pioneer, an apparent discrepancy. If more of the Jovian convection electric field had penetrated into Io connected field (higher ratio of Alfven wave conductance to Io conductance) during the Pioneer period than during the Voyager encounter, particle losses observed by Pioneer could be explained by precipitation at Io. Losses for both energetic electrons and protons at Io are calculated for different amounts of electric field shielding at Io. (Io, satellite absorption, energetic electrons).
J. Geophys. Res., Blue, Paper 3A0743

Seismology

6950 Seismic Sources
EARTHQUAKES IN THE OROZCO FRACTURE ZONE: SEISMICITY, SOURCE MECHANISMS, AND TECTONICS
A.M. Trehu (MIT/WHOI Joint Program in Oceanography, Cambridge, MA 02139; now at U.S. Geological Survey, Woods Hole, MA 02543) and S.C. Solomon
As part of the Rivera Ocean Seismic Experiment (ROSE), a network of ocean bottom seismometers and hydrophones was deployed in order to determine the seismic characteristics of the Orozco transform fault in the central eastern Pacific. We present hypocentral locations and source mechanisms for 70 earthquakes recorded by this network. All epicenters are within the transform region of the Orozco Fracture Zone and clearly delineate the active plate boundary. About half of the epicenters define a narrow line of activity parallel to the spreading direction and situated along a deep topographic trough which forms the northern boundary of the transform zone (region 1). Most focal depths for these events are very shallow, within 4 km of the seafloor; several well determined focal depths, however, are as great as 7 km. No shallowing of seismic activity is observed as the rise-transform intersection is approached; to the contrary, the deepest events are within 10 km of the intersection. First motion polarities for most of the earthquakes in region 1 are compatible with right lateral strike-slip faulting along a nearly vertical plane striking parallel to the spreading direction. Another zone of activity is observed in the central part of the transform (region 2). The apparent horizontal and vertical distribution of activity in this region is more scattered than in the first, and the first motion radiation patterns of these events do not appear to be compatible with any known fault mechanism. Pronounced lateral variations in crustal velocity structure are indicated for the transform region from refraction data and measurements of wave propagation directions. The effect of this lateral heterogeneity on hypocenters and fault plane solutions is evaluated by tracing rays through a three-dimensional velocity grid. While findings for events in region 1 are not significantly affected, in region 2 epicentral mislocations of up to 10 km and azimuthal deflections of up to 45° may result from assuming a laterally homogeneous velocity structure. When corrected for the effects of lateral heterogeneity, the epicenters and fault plane solutions for earthquakes in region 2 are compatible with predominantly normal faulting along a topographic trough trending NW-SE; the focal depths, however, are poorly constrained. These results suggest an en echelon spreading center or leaky transform regime in the central transform region.
J. Geophys. Res., Red, Paper 3B1055

6950 Seismic Sources (Mechanisms)
SYSTEMATIC CHANGE OF FOCAL MECHANISM WITH DEPTH IN THE WESTERN GREAT BASIN
U. R. Vetter and A. S. Ryall (Seismological Laboratory, University of Nevada, Reno, NV 89557)
For most areas in the western Great Basin focal mechanisms show a consistent pattern of primarily strike-slip motion for shallow events and oblique or normal slip for deeper events. However, orientation of the axis of least principal stress (T-axis) is different for different areas: NW-SE for western Nevada and the Mono Lake region, and NE-SW for the Mammoth Lakes area. Along the remainder of the Sierra Nevada frontal fault zone, T-axes show both orientations.
In general the change in mechanism with depth is interpreted as the result of increasing overburden pressure, resulting in rotation of the maximum compressive stress (P-axis) from horizontal at depths less than about 6 km to vertical at depths greater than about 9 km. The absence of normal-slip events at depths greater than 10 km in one area (Mono-Excelsior-Luning zone) may be explained by a larger horizontal compressive stress compared with areas that do have normal faulting at such depths. In some areas conjugate right- and left-lateral shear on nearly vertical fractures may be associated with the formation of clusters of magma-filled dikes at shallow depths.
Assuming strike-slip faulting to be characteristic of earthquakes with depth less than 6 km and normal faulting for events deeper than 10 km, extrapolation of measured shear stress in the upper few kilometers of the crust provides a rough estimate of the maximum and minimum principal stress as a function of depth. At about 3 km depth we find that both stresses are horizontal, with values of about 104 and 55 MPa, respectively. At depth of 20 km the maximum principal stress is vertical and equal to the overburden pressure, about 530 MPa; the minimum stress is horizontal and about 260–300 MPa.
J. Geophys. Res., Red, Paper 3B1077

6970 Structure of the crust and upper mantle
EARTHQUAKE LOCATIONS AND THREE-DIMENSIONAL CRUSTAL STRUCTURE IN THE COYOTE LAKE AREA, CENTRAL CALIFORNIA
C. H. Thurber (Department of Earth and Space Sciences, State University of New York, Stony Brook, N. Y. 11794)
Previous work on the simultaneous inversion method has been improved and extended to incorporate iterative solution for earthquake locations and laterally heterogeneous structure. Approximate ray tracing and parameter separation are important elements of the improved method. Application of the method to P-wave arrival time data recorded by stations of the US Geological Survey Central California Network yields a three-dimensional model for the velocity structure of the upper crust in an area encompassing the rupture zone of the Coyote Lake earthquake of August 1979. Very strong correlations between the velocity model and the geology and gravity and magnetic anomalies are observed. Improved estimates of the locations of earthquakes in the study area are also determined. The relocation of explosions indicates epicentral accuracies on the order of a kilometer or better. Based on the revised hypocentral locations, it is concluded that the San Andreas fault is vertical in this area, with no actual offset between the epicenters and the fault trace. In contrast the Calaveras has two (or more) active fault surfaces, one nearly vertical and another dipping 75° to the northeast.
J. Geophys. Res., Red, Paper 3B1076

6975 Structure of the earth's interior below the upper mantle
THE SHEAR-WAVE VELOCITY GRADIENT AT THE BASE OF THE MANTLE
Thorne Lay (Seismological Laboratory, California Institute of Technology, Pasadena, California 91125), Donald V. Helmberger
The relative amplitudes and travel times of ScS and S phases are utilized to place constraints on the shear-wave velocity gradient above the core-mantle boundary. A previously reported long-period ScSH/SH amplitude ratio minimum in the distance range 65° to 70° is shown to be a localized feature, apparently produced by an amplitude anomaly in the direct S phase, and therefore need not reflect the velocity gradient at the base of the mantle. The amplitude ratios that are free of this anomaly are consistent with calculations for the JB model or models with mild positive or negative velocity gradients in the lowermost 200 km of the mantle. ScSV arrivals are particularly sensitive to the shear velocity structure just above the core-mantle boundary. The apparent arrival time of ScSV is as much as 4 seconds greater than that of ScSH in the distance range 75° to 80° for Sea of Okhotsk events recorded in North America. This can be explained by interference effects produced by localized high velocity layer or strong positive S velocity gradient in the lowermost 30 km of the mantle. A velocity increase of about 5% is required to explain the observed shift between ScSV and ScSH. This thickness, high velocity layer varies laterally, as it is not observed in similar data from Argentine events. Refined estimates of the outermost core P velocity structure are obtained by modeling SKS signals in the distance range 73° to 85°.
J. Geophys. Res., Red, Paper 3B1110

6975 Structure of the earth's interior below the upper mantle
REFLECTION PROPERTIES OF PHASE-TRANSITION AND COMPOSITIONAL-CHANGE MODELS OF THE 670-KM DISCONTINUITY
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Seismic observations of the amplitude ratio amp P'670P'/amp P'P' suggest a reflection coefficient R ~ 7-13% for reflections from the underside of the 670-km discontinuity. This can be compared with calculated reflection coefficients to constrain the nature of the mantle transition region. Velocity and density profiles through the transition region were calculated for olivine, pyroxene, garnet, and olivine + garnet model mineral assemblages. For models with identical upper and lower mantle compositions, the computed reflection coefficients from the phase transitions pertinent to the 670-km discontinuity are less than 0.5%. These phase transitions produce their maximum R if they are effectively discontinuous, which gives R ~ 2-3%, except for the garnet to perovskite transformation which gives R ~ 5%. In general, phase changes must occur over a region less than 1 km thick for R to be on the order of 5%. A discontinuous change in chemical composition at 670 km depth, coupled with a change in phase, can also produce a reflection coefficient of the observed magnitude: R ~ 2-3% for a first order change in phase at 670 km with different iron concentrations on each side of the discontinuity, and R ~ 4-6% for cases with a discontinuous increase in silica content. Based on our analysis, the thermal and chemical boundary layers which would occur across such a chemical discontinuity would probably have negligible effects on the reflection coefficient. Thus although limited by considerable uncertainties, the mineralogical and seismic data suggest a two-layered model of the mantle with a discontinuous change in both phase and composition at 670 km.
J. Geophys. Res., Red, Paper 3B1069

Social Sciences

7310 Economics
ALTERNATIVE STRUCTURES FOR WATER RIGHTS MARKETS
J. Wayland Eheart (Department of Civil Engineering, University of Illinois, Urbana, Illinois 61801) and Randolph M. Lyon
The design of systems of marketable permits for water consumption from natural watercourses is examined. For the work reported upon here, the most important considerations are those associated with: 1) uncertainty of future streamflows and economic conditions, 2) locational issues, and 3) efficient and effective functioning of the markets. Particular attention is given to the problem of implementing marketable rights systems in regions presently following the riparian doctrine. In these regions the most important design decisions include: the basis of definition of permits, the means for initially distributing them, the type of market mechanism used for their transfer after they are issued, and the restrictions placed on their use and transfer. These design decisions are examined here with respect to program objectives including: economic efficiency, equity, ease of administration and implementation, and maintenance of instream flows. Alternative approaches to the design problems are discussed and trade-offs implied by the decisions are identified.
Water Resour. Res., Paper 3W0652

Solar Physics, Astrophysics, and Astronomy

7720 (Electromagnetic Radiation)
THE SOLAR ABSOLUTE SPECTRAL IRRADIANCE AT 1216 A AND 1800-3173 A: 12 JANUARY 1983
G.H. Mount (Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309), G.J. Rottman
The full-disk solar spectral irradiance in the spectral range 1800-3173 Å and at Ly α was obtained from a rocket observation above White Sands Missile Range, New Mexico, on 12 January 1983. Comparison with measurements made in May 1982 show no changes within the absolute errors of the experiment. The absolute calibration of the instruments for this flight was accomplished at the National Bureau of Standards Synchrotron Radiation Facility.
J. Geophys. Res., Green, Paper 3C0941

7770 Sunspots (Prediction)
THE VISUAL AURORA AS A PREDICTOR OF SOLAR ACTIVITY
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Auroral occurrence frequency may be used as proxy data for solar activity. In recent years magnetic data and auroral data during the declining phase of one sunspot cycle have been used to predict the maximum sunspot number of the following cycle. This paper discusses appropriate use of auroral data for this purpose, and tests the validity of such a procedure for the period 1721-1943. The results show that the use of auroral sums for sunspot minimum and the preceding three years can predict the subsequent sunspot number maximum, but that the predictor involves two branches. One, fitting the majority of observations, may be considered the normal branch. The other, called here the deficit branch, gives fewer auroral occurrences than would be expected. Treatment of magnetic activity data in the same fashion gives similar, but not identical results. (sunspots, auroras, solar activity prediction).
J. Geophys. Res., Blue, Paper 3A0733